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British Society of Animal Science

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The prediction of food intake of lactating dairy cows offered grass silage or mixed forage-based diets throughout lactation

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Introduction Accurate prediction of daily food intake is a fundamental pre-requisite of any nutritional model designed to provide feeding recommendations for lactating dairy cattle. From an evaluation of five of the most commonly used models to predict food intake, Keady *et al.* (2001) observed a considerable range of accuracy of prediction, with some under-predicting intake by 0.9 kg DM/cow/day, whilst others over-predicted intake by up to 2.9 kg DM/cow/day. The aim of the current study was to develop a model, encompassing both animal and feed variables, which accurately predicts food intake of lactating dairy cattle offered a range of diets in production systems currently employed on dairy farms. The new model has been adopted to predict food intake in the Feed into Milk (FIM) rationing system.

Materials and Methods Data from a total of 35 studies in which grass silage was offered as the sole forage, or in combination with other forages, with a wide range of concentrate supplements, were used to develop the FIM intake model. Thirteen studies from the Agricultural Research Institute of Northern Ireland, 9 from ADAS Bridgets, 10 from the Scottish Agricultural Colleges, and 3 from the Centre of Dairy Research (CEDAR), University of Reading, were used. A variety of multi-variate methods including stepwise multiple regression, best subsets multiple regression, partial least squares regression and principal components regression were used to derive prediction equations based on the dataset.

Results The final dataset contained information on 3337 lactating dairy cows and embraced a wide range of diet and cow characteristics. For example, intakes of grass, maize and whole crop wheat silages, concentrate and total dry matter varied from 1.6 to 18.8; 4.8 to 12.3; 5.8 to 11.3; 1.5 to 21.4; and 8.5 to 29.4 kg DM/cow/day respectively. Milk yield, live weight and week of lactation varied from 7.7 to 49.7 kg/day; 351 to 851 kg; and 2 to 44 weeks respectively. The final model was developed using stepwise multiple regression analysis which produced a model with the most biologically sensible coefficients and also the model which performed best when tested on independent datasets. The FIM intake model is outlined below:

$$TDMI = -7.68 + 0.1033\ FIP - 0.00814\ (FIP^{*}\ CDMI) - 1.1185\ CS + 0.01896\ W + 0.7343\ CDMI - 0.00421\ CDMI^{2} + 0.04767\ MEO - 6.43\ (0.6916^{WL}) + 0.007182\ FS \times 0.001988\ (CCP \times CDMI) \quad \text{(Equation 1)}$$

where: TDMI = total dry matter intake (kg DM/day); FIP = forage intake potential (g DM/kg $W^{0.75}$); CDMI = concentrate DM intake (kg/day); CS = condition score; W = live weight (kg); MEO = milk energy output (MJ/day); FS = forage starch (g/kg forage DM); WL = week of lactation; CCP = concentrate crude protein (g/kg DM).

An equation was also produced which excluded concentrate crude protein concentration to overcome limitations in some computing software. This model is:

$$TDMI = -7.38 + 0.1018\ FIP - 0.00795\ (FIP^{*}\ CDMI) - 1.065\ CS + 0.01929\ LW + 0.954\ CDMI + 0.00364\ CDMI^{2} + 0.05204\ MEO - 6.894\ (0.6932^{WL}) + 0.010747\ FS \quad \text{(Equation 2)}$$

Two independent datasets were created using treatment mean data from the literature. These were used to test the new model (Equation 1) and the best model currently available to the industry (Vadiveloo and Holmes, 1979). The validation statistics, presented in Table 1, illustrate that regardless of the basal forage, the new intake equation was more accurate at predicting food intake than Vadiveloo and Holmes (1979). For grass silage and mixed forage-based diets the new model over-predicted intake by only 0.02 and 0.01 respectively. In contrast, Vadiveloo and Holmes (1979) over-predicted intake of grass silage-based diets by 0.4 and under-predicted intake of mixed forage-based diets by 0.08.

Table 1 Comparison of precision of intake prediction of the Feed into Milk (FIM) (Equation 1) and Vadiveloo and Holmes (V&H) (1979) intake models for diets of grass silage and mixed forage-based diets.

	TDMI (kg/day)						Proportion of MSPE		
Model	Actual	Predicted	Bias	R^2	MSPE	MPE	Bias	Line	Random
Grass silage as sole forage (n = 34)									
FIM (Equation 1)	16.6	16.3	-0.3	0.93	0.658	0.049	0.08	0.05	0.87
V&H	16.6	17.3	0.6	0.87	1.480	0.074	0.24	0.05	0.71
Mixed forage-based diets (n = 10)									
FIM (Equation 1)	18.0	18.2	0.2	0.75	0.519	0.040	0.09	0.01	0.91
V&H	18.0	16.5	-1.5	0.62	3.020	0.097	0.70	0.06	0.24

Conclusions The new intake prediction model, which is used in the FIM rationing system, represents a major advance in predicting food intake across a wide range of diet types and is much more appropriate for today's dairy cow, compared to models widely used in the industry at present.

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Development of a new approach to determine the energy requirements of dairy cows

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Introduction One of the cornerstones in the development of a new feed rationing system for dairy cows must involve a reappraisal of both the concepts and 'numbers' adopted in defining the energy requirements for dairy cows. This is particularly important in the present scenario where increasingly high levels of animal output are being achieved from very different animal genotypes to those used in UK dairying 20 - 30 years ago. One of the tasks within the FEED INTO MILK (FIM) project was to develop a new system to predict the energy requirements of todays dairy cow. The objective of the present study was to collate all available energy metabolism data with dairy cows in the UK and to develop relationships for describing metabolisable energy (ME) requirement for maintenance (ME_m) and efficiency of ME use for lactation (k_l) using both existing and new methodologies.

Material and methods Recent calorimetric data of dairy cows (n = 642) from four UK sources (ARINI, CEDAR, DANI and GRI) were collated and verified. The data verified were derived from lactating dairy cows at various lactation stages and lactation number and of different genetic merits, and offered forage-based diets at restricted or production feeding levels. The forages used included grass silage, maize silage, grass hay and fresh grass. Five functions (linear, Mitscherlich, rectangular hyperbola, logistic and Gompertz) were considered to relate milk energy output (corrected for negative energy balance, $E_{l(0)}$, MJ/kg$^{0.75}$) to ME intake (corrected for energy used for live weight gain, MEI, MJ/kg$^{0.75}$). The near zero energy balance data (± 5 MJ/d) within the whole data set were selected for determining ME_m and k_l using the linear regression between milk energy output against MEI. These two values were subsequently used to derive efficiency of ME utilisation for live weight gain and efficiency of utilisation of mobilised energy for lactation, using positive and negative energy balance data, respectively. These two efficiencies were then used for calculating $E_{l(0)}$ and MEI for the whole data set.

Results The residual sum of squares and variation in the data explained by fitting the functions (R^2) were similar across all five models. The non-linear functions showed the effects of level of feeding very clearly and allowed calculation of an overall k_l, and k_l within a specific range of ME intakes, while the linear model provided a value of k_l that does not change with the level of feeding. The rectangular hyperbola approach gave large s.e. values with its parameter estimates. The logistic and Gompertz models tended to underestimate milk energy at higher levels of feeding and the efficiency of utilisation of ME for maintenance. Among the five functions considered, the Mitscherlich model gave relatively lower s.e. values and the parameter estimates made biological sense. After examining the derived s.e. and R^2 values, a fasting metabolism (FM) value of 0.453 MJ/kg$^{0.75}$ for dairy cattle, as reported by Yan et al. (1997), was taken as FM for the Mitscherlich model. This function is given below and the plot is presented in Figure 1.

$$E_{l(0)} = 5.06 - (5.06 + 0.453) * EXP(-0.1326 * MEI) \qquad R^2 = 0.85$$

The relationship generates a fixed ME_m of 0.647 MJ/kg$^{0.75}$, but various k_l values depending on feeding level (mean k_l = 0.605). On further examination of the relationship, a minimum k_l of 0.59 should be adopted as this represents the present limits of the data-set. The Mitscherlich fit to the whole data-set was compared to fits obtained using sub-sets of the data to investigate the effects on the relationship of a number of factors such as: site; cow genetic merit; forage type; forage:concentrate ratio; diet fibre content; stage of lactation; and cow condition score. Although there were differences in the derived Mitscherlich equations for these various sub-sets, in no case were they statistically significant.

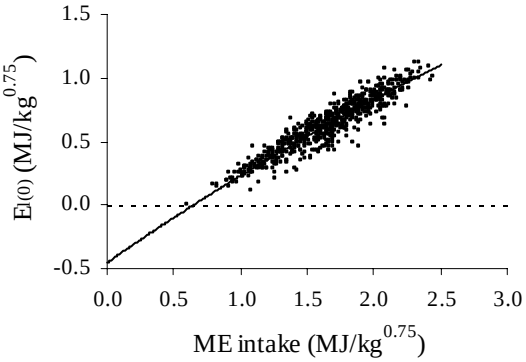

Figure 1. The Mitscherlich relationship

Conclusion A new modelling approach was developed to interpret the calorimetric data. This model allows simultaneous calculation of a fixed ME_m and various k_l values according to feeding level.

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Evaluation of a revised energy rationing model for dairy cattle

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Introduction The Feed into Milk (FIM) project in the United Kingdom has developed a Mitscherlich equation from calorimetric data for energy rationing of dairy cattle (Agnew *et al.*, 2004). The objective of the present study was to evaluate this equation using independent data sets obtained in both calorimetric and production studies.

Material and methods Three data sets for dairy cows were used, i.e. published calorimetric data (n = 42), ARINI+Moorepark production data (n = 121) and FIM production data (n = 2526). The first data set was derived from published studies in which energy metabolism data were measured in calorimetry. The second data set was obtained from production studies undertaken at this Institute and Moorepark Research Centre, in which metabolisable energy (ME) concentration in diets was estimated from digestible organic matter in total dry matter (DOMD) with dairy cows fed at production level. The third data set was obtained from production studies undertaken in four research centres (this Institute, Scottish Agricultural College, Agricultural Development and Advisory Service and Reading University). In these studies ME concentrations in forages were estimated from DOMD which were either measured or predicted at maintenance feeding level and ME concentrations in concentrates were taken from tabulated values. These data were then used to calculate ME concentrations in mixed diets at production feeding levels. The mean square prediction error (MSPE) technique was used on the three data sets to evaluate actual vs. predicted (Agnew *et al.*, 2004) ME intake.

Results The result of the evaluation is presented in Table 1. The majority of prediction error was derived from the random variation with each data set. The published calorimetric data and FIM production data had a small proportion of error derived from the line (slope), while this error was relatively large with the ARINI+Moorepark production data. However, with all three data sets, this equation over-predicted ME intake by 6.2 to 9.6 MJ/d. The over-prediction resulted in a relatively large proportion of error derived from bias with the published calorimetric data, but this error was relatively small with the ARINI+Moorepark and FIM production data sets. The residual plot technique was also used to evaluate the FIM Mitscherlich equation by using predicted ME intake (x axis) against residual ME intake (predicted – actual) (y axis) (Fig. 1). Although over half of plots were over the zero line with each data set, the majority of the plots were distributed around the zero line. The s.d. values for the residual plots were 10.1, 16.8 and 23.3 MJ/d with the published calorimetric data, ARINI+Moorepark production data and FIM production data, respectively.

Table 1. Evaluation of the FIM Mitscherlich equation (Agnew *et al.*, 2004)

	ME intake (MJ/d)					Proportion of MSPE		
	Predicted	Actual	Bias	s.e.	MSPE	Bias	Line	Random
Published calorimetric data	188	181	7.0	10.2	149	0.33	0.07	0.60
ARINI+Moorepark production data	203	197	6.2	16.8	318	0.12	0.20	0.68
FIM production data	215	206	9.6	22.3	648	0.14	0.04	0.82

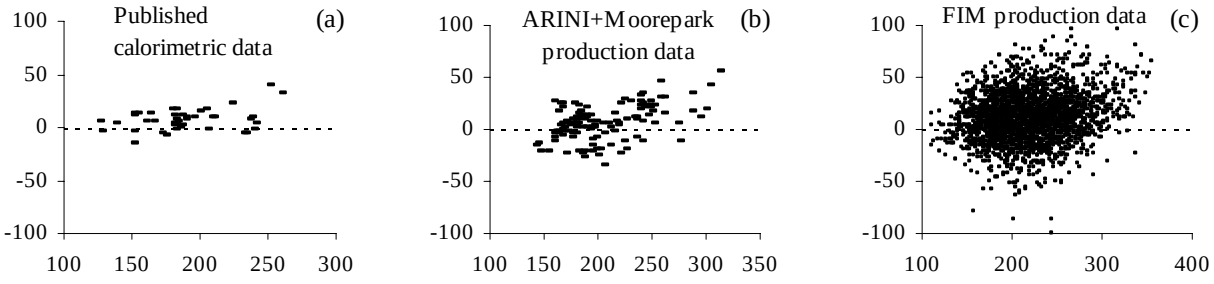

Figure 1. The relationships between predicted ME intake (x axis) and residual ME intake (y axis) (MJ/d)

Conclusion The majority of prediction error was derived from random variation, indicating that the FIM Mitscherlich equation accurately predicted ME intake, although there was a small over-prediction.

Acknowledgement This study was funded by DEFRA, DARDNI, SEERAD, MDC and a consortium of industrial partners within a LINK Sustainable Livestock Production project: Feed into Milk.

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The effects of maize and whole crop wheat silages on the performance of lactating dairy cows offered two levels of concentrates differing in protein concentration

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Introduction Under Northern Ireland conditions, Keady *et al.* (2002, 2003) obtained positive responses in milk production to the inclusion of maize silage in grass silage-based diets. However, while the area of forage maize is increasing, there is considerable interest in the production of whole crop wheat as a forage for feeding to lactating dairy cows. The objective of the study was to examine the responses of lactating dairy cows to the inclusion of maize silage or fermented whole crop wheat silage in grass silage-based diets. Furthermore, the concentrate sparing effects of maize and wheat silage were determined. Finally the effect of protein level in the concentrate supplement when offered with the different forages, was evaluated.

Materials and methods Silages were prepared from first cut grass, forage maize which had been sown under complete cover plastic mulch and a winter wheat crop respectively. Three forage combinations were offered *ad libitum* and comprised either grass silage (GS) as the sole forage, grass silage/maize silage (MS) or grass silage/whole crop wheat (WS) at ratios of 60:40 (DM basis). The grass, maize and wheat silages had: DM, 187, 297 and 316 g/kg; pH, 4.27, 3.99 and 4.28; CP, 113, 77 and 96 g/kg DM; starch (NIR), 0, 294 and 260 g/kg DM; ME (NIR) 11.2, 11.3 and 9.9 MJ/kg DM. The forages were supplemented with two levels of concentrates, namely 8 and 12 kg/d. The low level of concentrates was offered at 4 levels of crude protein in the concentrate, namely 180, 230, 280 and 330 g/kg, while the high level was offered at 130, 180, 230 and 280 g/kg. The 24 treatments were offered to 60 lactating dairy cattle in a partially balanced, changeover design study consisting of four periods of 4 weeks, with the final week of each period being used as the main recording interval. The forages were mixed in a diet mixer and offered through electronic gates linked to a system which automatically recorded the forage intakes of individual cows which shared the feed station. The concentrate contained starch (150 g/kg DM) and was offered separately from the forage through out-of-parlour feeders. The results were subjected to statistical analysis using the REML technique in Genstat 5.

Results Level of protein in the concentrate had no significant effect (P>0.05) on feed intake, milk yield or milk composition. The effects of forage treatment and level of concentrates on animal performance are presented in Table 1. The MS and WS treatments significantly increased forage DM intake by 0.25 and 0.23 respectively on a proportional basis, but only the MS forage treatment produced a significant increase in milk yield and yield of fat plus protein. Forage treatment had no significant effect (P>0.05) on milk composition. The higher level of concentrate feeding reduced the intake of forage but increased total diet intake, milk yield, protein concentration and yield of fat plus protein. A significant interaction (P<0.01) was obtained between forage treatment and level of concentrates for milk yield, i.e. the responses to MS and WS versus GS at the low level of concentrates were 2.4 and 2.2 kg/d (P<0.05) respectively, while the responses at the high level of concentrates were 0.9 and –0.8 kg/d respectively (P>0.05). On the basis of responses in yield of fat plus protein, the concentrate sparing effects of the MS and WS forage treatments were 1.3 and 0.5 kg concentrates/cow/d.

Table 1 The effects of forage treatment and concentrate level on performance

	Forage (F)[1]				Concentrate (C)			Significance		
	GS	MS	WS	SED	Low	High	SED	F	C	FxC
Intake (kg DM/d)										
Forage	7.86[a]	9.81[b]	9.63[b]	0.250	9.75	8.57	0.134	***	***	NS
Total	16.10[a]	17.90[b]	17.67[b]	0.269	16.32	18.27	0.139	***	***	NS
Milk yield (kg/d)	25.8[a]	27.4[b]	26.5[ab]	0.54	25.1	28.3	0.30	**	***	**
Butterfat (g/kg)	39.8	39.0	39.0	1.21	39.2	38.8	0.59	NS	NS	NS
Protein (g/kg)	30.9	31.5	31.3	0.44	30.6	31.9	0.22	NS	***	NS
Fat + protein yield (g/d)	1815[a]	1938[b]	1861[ab]	43.8	1743	2005	24.7	*	***	NS

[1] Means with differing superscripts are significantly different (P<0.05)

Conclusion Level of protein in the concentrate had no significant effects on performance. While the alternative forages increased total forage intake, the inclusion of maize silage significantly increased the yields of milk and fat plus protein, whereas the inclusion of whole crop wheat silage did not significantly affect animal performance. The responses to the inclusion of the alternative forages were reduced at the higher level of concentrate feeding. Forage maize had a greater concentrate sparing effect than wheat silage.

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Structure changes in bacterial populations from the phylum *Bacteroidetes* upon the inclusion of monensin, cinnamaldeyhde or garlic extract in a dual flow continuous culture system

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Introduction As a consequence of the anticipated ban on all in-feed antibiotics in the European Union, novel alternatives are being intensively investigated in the adult ruminant area. Previous reports have documented the potential of natural plant extracts and their principle components to modify rumen dynamics *in vitro* (Evans and Martin, 2000; Wallace *et al*., 2002). However, more data needs to be accumulated on the underlying mechanism of action of these phytocompounds on the rumen microflora. The aim of this study is to use molecular methods in order to elucidate the effects of two plant extracts, namely cinnamaldehyde and garlic extract in comparison to the ionophore antibiotic monensin on the structure of the microbial community in a rumen-simulating dual flow continuous culture system.

Materials and methods Samples were obtained from an *in vitro* screening of plant extracts described by Busquet *et al*. (2003). Fermenters were inoculated with rumen fluid from two Spanish Holstein heifers in three consecutive periods (named P1, P2 and P3), fed a 50:50 forage-to-concentrate diet and supplemented with two different doses of monensin (MON 4, 4 mg/d as fed; MON 40, 40 mg/d as fed), cinnamaldehyde (CIN 100, 100 mg/d as fed; CIN 1000, 1000 mg/d as fed), or garlic extract (GAR 100, 100 mg/d as fed; GAR 1000, 1000 mg/d as fed). Two fermenters served as controls. Total microbial DNA was isolated from fermenter samples (Reilly and Attwood 1998). DNA yields and purity were determined spectrophotometrically using the Warburg Christian equation. The primer BacPre (Avguštin *et al.*, 1994) was used for specific amplification of the 16S rRNA genes from bacteria belonging to the phylum *Bacteroidetes*, representing the major Gram-negative bacterial population in the rumen. Amplified ribosomal DNA restriction analysis (ARDRA) was performed on Bioanalyser 2100 (Agilent Technologies, USA) using DNA 7500 LabChip® kit. Eub338/BacPre primer pair was used in real-time PCR experiment on ABI PRISM™ 7700 Sequence Detection System.

Results The average DNA yield and determined *Bacteroidetes* cell numbers are shown in Table 1. The yield of total microbial DNA was in all cases reduced after the treatment with each of the tested additives. The ARDRA analysis results showed that yet uncharacteristed bacterial groups belonging to the phylum *Bacteroidetes* exist in Spanish cattle rumen fluid and that the additives tested exhibited different effects on these subpopulations. Garlic extract (GAR100) was the one that affected the size of particular subpopulations of the ruminal *Bacteroidetes* to the greatest extent. When considering total *Bacteroidetes* population, monensin had the most pronounced stimulating effect, whereas the lower concentration of cinnamaldehyde was the only one that suppressed the *Bacteroidetes* numbers (see Table 1, Row D).

Table 1. Effect of different doses of monensin, cinnamaldehyde and garlic extract on the average (A) DNA yield and (B) number of BacPre recognized cells/mL of fermenter samples. (C) expected number of BacPre cells according to the A/B ratio in control samples. (D) Ratio between enumerated (B) and expected (C) number of BacPre cells. Arrows indicate quantitative changes of BacPre population in fermenter samples.

P1/P2/P3 average		CTR	MON4	MON40	CIN100	CIN1000	GAR100	GAR1000
A	DNA (µg/ml) yield	1015	483	328	808	510	600	482
B	number of BacPre cell equivalents (x10^9)/mL sample	2,6	1,9	4,5	1,8	3,6	1,9	2,5
C	expected B	2,6	1,2	0,8	2,1	1,3	1,5	1,2
D	B/C x100 [%]	100	158 ↑	562 ↑↑↑	86 ↓	277 ↑↑	127 ↑	208 ↑↑

Conclusions All three feed additives tested in this study, with the exception of cinnamaldehyde in lower concentration, appear to inhibit predominately Gram-positive bacteria. Namely, total microbial DNA yield in all treatment samples was reduced substantially, whereas the *Bacteroidetes*, *i.e.* dominant Gram-negative bacterial population, cell numbers increased in some cases and were reduced to a lesser extent in other cases. This is in agreement with published data on greater resistance of Gram-negative bacteria due to the protective outer cell envelope.

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Effects of short-term grazing on bioactive forages on lambs artificially infected with *Teladorsagia circumcincta*

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Introduction Ruminants grazing on forages that contain condensed tannins (CT) have lower parasite burdens compared to those grazing on similar quality, tannin-free forages (Min and Hart, 2003). Evidence from previous grazing studies suggested that chicory, which contains only traces of CT, could also reduce the size of the parasite population carried by ruminants (Hoskin et al. 1999). Such bioactive plants may have direct anthelminthic effect on different developmental stages of the worms or indirect effects through nutritional improvement of host immunity. The purpose of this study was to determine whether short-term grazing of bioactive forages could affect either the established adult population or incoming infective larvae of *Teladorsagia circumcincta* a common abomasal parasite of sheep. The bioactive species tested were chicory (*Chicorium intybus*) and the CT-containing plants: lotus (*Lotus pedunculatus)*, sainfoin (*Onobrychis viciifolia)* and sulla (*Hedysarum coronarium*).

Materials and methods Sixty, parasite naive, three-month-old Texel × Scottish Greyface sheep (live-weight 29.4 ±0.59 kg) were dosed with 8,000 infective larvae of *T. circumcincta* on day 1 of the experiment. All sheep remained onto parasite-free grass/clover pastures until day 21, when they were allocated to ten groups (n=6) based on their faecal egg counts (FEC) and their bodyweight. Two groups were allocated to two control, grass/clover (*Lolium perenne/Trifolium repens*) plots (0.1 ha each), while the remaining groups were allocated to the bioactive forages (two replicate plots of 0.1 ha for each forage). On day 28 of the experiment a second dose of 8,000 infective larvae of *T.circumcincta* was administered to the sheep to investigate the effects of the bioactive forages on the establishment of infective larvae. The animals remained on the experimental plots until day 35, when they were slaughtered for worm recovery. FEC repeated measurements for each animal were plotted and the "area under curve" was calculated. The resulted FEC-area values and worm burdens were log-transformed ($\log_{10}(x+1)$) and analysed using ANOVA.

Results There were no differences observed between the two replicates for each forage species. FECs and areas under the curve were similar between sheep grazing on different forages (Fig.1). Lambs grazing chicory had the lowest adult worm burdens and significantly lower numbers of male worms compared to those grazing on grass/clover (P=0.022) (Fig.2). Female worm burdens were not different among the forage treatments. The feeding treatments also affected (P<0.001) the numbers of immature worms recovered from sheep; sulla-fed animals had the lowest immature burdens and lotus-fed the highest. Live-weight gains during this two-week period were not different among the groups and averaged 231±26 g/day.

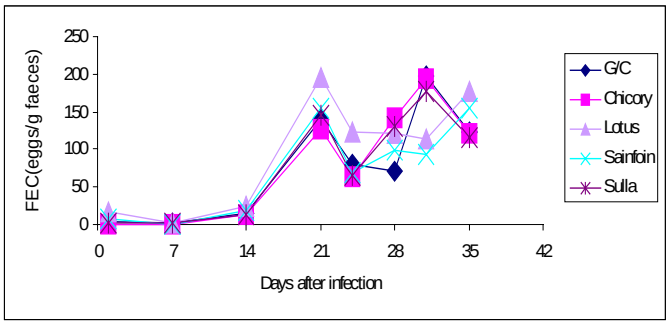

Figure 1: Faecal egg counts (eggs per g fresh faeces) of lambs grazing on five different forages (arithmetic means)

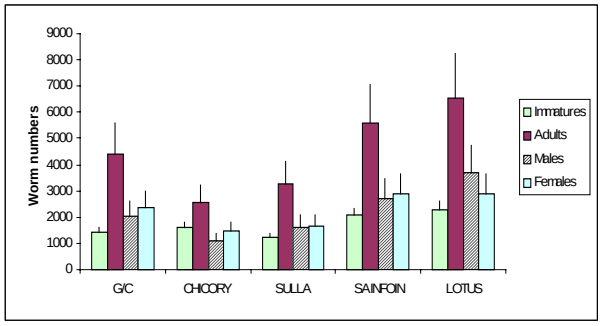

Figure 2: Immature, adult, male and female worm burdens recovered from lambs grazing on five different forages (backtransformed means with 95% CI)

Conclusions The results of this study provide some support to the view that short-term grazing on certain bioactive forages, such as chicory, could be used as a means of reducing *T. circumcincta* burdens. Given that there were no obvious effects of any of the forages on egg counts and that the sheep were infected twice, it is difficult to distinguish whether the reduction in adult *T. circumcincta* population seen in sheep grazing chicory was attributable to a direct anthelmintic effect and/or to an immunologically mediated indirect effect. Further studies are required to investigate the potential of bioactive forages and to elucidate the relative importance of directly and indirectly mediated effects on worm populations in growing lambs.

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Effects of protein supply on immunity to *Trichostrongylus colubriformis* in lactating ewes

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Introduction It has been suggested that the periparturient breakdown of immunity to parasites has a nutritional basis (Coop and Kyriazakis, 1999). The often observed breakdown of immunity to abomasal nematodes in lactating sheep is indeed sensitive to metabolizable protein (MP) scarcity (Houdijk et al., 2003). However, a periparturient breakdown of immunity to intestinal nematodes is less likely to occur (Jackson et al., 1988). This discrepancy suggests that immunity to abomasal and intestinal nematodes may differ in their sensitivity to changes in MP supply. The objective of this experiment was to assess whether immunity to intestinal nematodes in lactating sheep is sensitive to MP supply.

Materials and methods Forty twin-bearing ewes were trickle infected with the intestinal nematode *Trichostrongylus colubriformis* (5,000 infective larvae per day, three days per week) from day_{-46}, relative to expected parturition, onwards. The daily allowance of hay and pelleted concentrates was calculated to provide 0.8 times MP requirements during late pregnancy. After parturition, five groups of eight ewes each were fed one of five foods, whose allowances were calculated to provide 0.60, 0.75, 0.90, 1.05 or 1.20 times the MP requirements during lactation (AFRC, 1993). Allowances were calculated to provide 0.9 times the metabolizable energy requirement. Ewes and lambs were weighed regularly, and faecal egg counts (FEC, in eggs per gram faeces, epg) were assessed from day_{-37} until day_{28}. Mean faecal output was assessed for five days around day_{20} using the n-alkanes methodology, and was used to calculate mean daily nematode egg output (DEO, eggs/day) over this period, which coincides with the expected peak lactation in sheep. FEC and DEO were log-transformed, and are reported as back-transformed means with 95% confidence intervals. ANOVA was used to assess changes in ewe body weight, calculated milk production (from lamb weight gain) and DEO. A repeated measurement ANOVA was used to analyse FEC during lactation, which included mean FEC during pregnancy as a covariate ($P<0.001$).

Results Mean ewe and litter weight (± se) at lambing was 55.5±0.6 and 8.3±0.12 kg, respectively. MP supply did not affect the rate of ewe body weight loss, which averaged 71 g/day (s.e. 22). The range of MP supply achieved did not affect FEC during lactation. Figure 1 shows the mean milk production (±s.e.), FEC and DEO around day_{20}. MP supply affected calculated milk production ($P<0.001$) but did not affect FEC ($P=0.32$). However, MP supply reduced faecal output ($P<0.05$), and consequently, MP supply tended to decrease DEO ($P=0.11$).

Conclusion The milk production data indicate that achieved MP supply in this experiment ranged from scarce to more than adequate. Whilst MP supply affected immunity to abomasal nematodes within such a range (Houdijk et al., 2003), the current results indicate that immunity to intestinal nematodes in lactating sheep is less sensitive to MP supply. It can, however, not be excluded that a larger range of MP supply than that achieved would be needed to test for a nutritional basis of breakdown of immunity to intestinal nematodes. The study supports the view that the possibility of using improved nutrition as a means of parasite control depends on the nematode species involved.

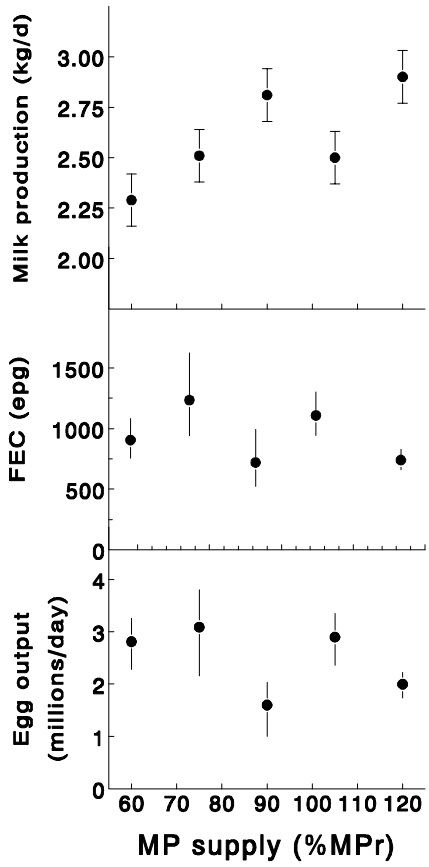

Figure 1. Milk production, faecal egg counts and egg output around day_{20} into lactation of twin-rearing ewes, fed at different levels of their MP requirement.

Acknowledgements This work was supported by BBSRC and SEERAD.

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The effect of maternal body reserves at lambing on nematode faecal egg output in lactating, organically managed ewes

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Introduction A hypothesis for the role of improved ewe nutrition, notably protein, in reducing the peri-parturient rise (PPR) in nematode faecal egg output has been developed by Coop and Kyriazakis (1999). More recently this hypothesis has been tested in field studies with organically managed ewes (Keatinge et al, 2003). It might also be expected that maternal body reserves could affect the potential availability of nutrients for further metabolism by the host animal. The objective of this experiment was to assess the effect of ewe body condition at lambing, on animal performance parametres and the PPR in ewe faecal egg output.

Materials and Methods Forty two, twin-bearing, multiparous Scottish Blackface ewes were managed to achieve two target body condition scores (High - CS 3; or Low - CS 2) at lambing. After lambing, ewes from both groups were paired on the basis of lambing date, body condition score and live weight. Each pair was randomly allocated to one of three grazing plots, each sub-divided into two 0.45 ha paddocks. For each treatment, three groups of ewes (n=7) and their twin lambs were grazed separately (16 ewes/ha) on one of six paddocks available. Sward height was maintained at 4 – 6 cm. For both treatments, ewes were supplemented with 0.9 kg per day freshweight of home-mixed organic concentrate, until sward height reached 5 cm. Ewe live weight, body condition score, blood betahydroxybutrate (BHB), faecal egg counts (FEC) and lamb live weight were measured weekly. Ewes were ultrasonically scanned for backfat and muscle depth two weeks before lambing, and at fortnightly intervals from two weeks after lambing. Continuous data were analysed by ANOVA in GENSTAT. Condition score data were analysed by Friedmans test. FEC data were log-transformed before analysis, and are reported as backtransformed means with 95% confidence intervals.

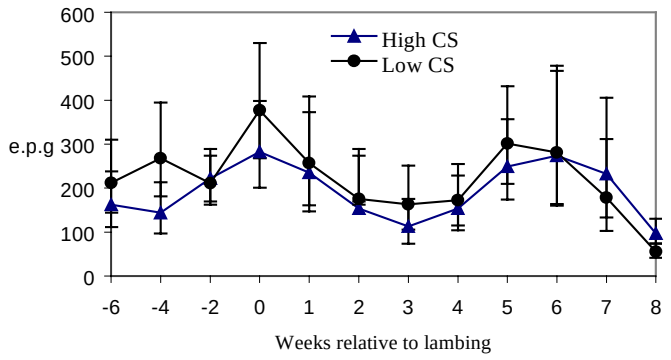

Figure 1

Results Significant treatment differences in ewe live weight and body condition score were established by lambing, and maintained during early lactation (Table 1). From ultrasound scanning data, High CS ewes had significantly greater backfat ($P < 0.05$) and muscle ($P < 0.01$) depth during early lactation. There were no significant differences in ewe blood BHB level. Faecal egg output followed a typical temporal pattern, but there was no significant effect of treatment (Fig. 1). Although mean litter weights at eight weeks of age were 1.0 kg heavier for High CS ewes, overall differences in lamb live weight were not statistically significant.

Table 1. Changes in ewe body condition score, live weight and muscle depth.

Week relative to lambing	Body condition score (median) High CS	Low CS	*P value*	Ewe live weight (kg) High CS	Low CS	P value	Week Relative to lambing	Muscle depth (mm) High CS	Low CS	*P value*
L – 2	2.75	2.00	*P<0.001*	67.2	60.9	*P<0.001*	L – 2	23.1	22.2	*P=0.25*
L	3.00	2.00	*P<0.001*	59.9	55.9	*P<0.001*	L + 2	23.2	20.9	*P <0.05*
L+ 2	2.88	2.13	*P<0.001*	60.6	55.6	*P<0.05*	L + 4	24.0	20.9	*P< 0.001*
L + 4	2.75	2.00	*P<0.001*	61.1	56.4	*P<0.05*	L + 6	24.1	21.2	*P < 0.05*
L + 6	2.63	2.13	*P<0.001*	61.3	56.7	*P<0.05*	L + 8	24.3	21.1	*P < 0.05*
L + 8	2.62	2.37	*P<0.001*	58.3	54.3	*P = 0.06*				

Conclusions The results suggest that 1) maternal body reserves are less important to the expression of PPR than current nutritional status, or 2), within this experiment the level of post-lambing feeding imposed on mature Scottish Blackface ewes was not sufficiently challenging to allow any potential effects of body condition to be expressed. Conversely, good nutrition in early lactation can, at least to some degree, ameliorate the potential impact of reduced body condition on faecal egg output.

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Changes in protein supply rapidly affect immunity to nematodes in lactating ewes

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Introduction There is an increasing body of evidence to support the view that the periparturient breakdown of immunity to parasites has a nutritional basis; an increased supply of metabolizable protein (MP), at times of MP scarcity, would reduce abomasal nematode egg excretion and worm burdens in periparturient ewes (Houdijk et al., 2001). It has been suggested that an increased MP supply may rapidly improve expression of immunity to gastrointestinal nematodes; immunity improved within one week when the MP demand of lactating ewes was reduced, at times of MP scarcity (Houdijk et al., 2003). Here, it was assessed if changes in MP supply can result in similarly rapid changes.

Materials and methods Twenty-four twin-bearing Greyface ewes were trickle infected with 10,000 infective *Teladorsagia circumcincta* larvae per day, three days per week, from day_{-58} onwards (relative to expected parturition). Until day_{-21}, all ewes were fed daily allowances, calculated to supply 0.7 times their MP and metabolizable energy (ME) requirements (AFRC, 1993). From day_{-21} until day_{10} (Period 1), ewes were fed daily allowances that were calculated to supply either 0.75 (L) or 1.25 (H) times their MP requirements (n=12). From day_{10} until day_{42} (Period 2) the feeding treatments were either the same (LL, HH; n=6) or crossed over (LH, HL; n=6). All periparturient allowances were calculated to supply 0.9 times ME requirements. The body weight of the ewes and lambs, and the ewe faecal egg counts (FEC, in eggs per gram fresh faeces, epg) were assessed up to twice weekly. FEC were log-transformed, and reported as backtransformed means with 95% confidence intervals. Repeated measures ANOVA was used to assess the effect of feeding treatment on ewe and litter body weight and FEC.

Results Figure 1 shows the mean body weight (±se) and FEC of the ewes. The L ewes were lighter than the H ewes during Period 1 ($P<0.05$), but not during Period 2. After the cross over, the LH and HL ewes rapidly increased and decreased weight, respectively. On average, the LH ewes were heavier than the other ewes during Period 2 ($P<0.05$). MP supply did not affect litter birth weight, averaging 8.5 kg (s.e. 0.39), but L and H litters weighed 12.7 and 15.3 kg by day_{10}, respectively (s.e.d. 0.51; $P<0.001$) and LL and HH litters weighed 23.4 and 28.3 kg by day_{37}, respectively (s.e.d. 1.30; $P<0.001$). Following the cross over, the weight gain of the LH and HL litters increased and decreased, respectively, weighing on average 25.1 kg (s.e. 1.3) by day_{37}. MP supply did not affect FEC during pregnancy but L ewes had higher FEC than H ewes during lactation ($P<0.01$), and LL ewes had higher FEC than HH ewes during most of Period 2 ($P<0.05$). Following the cross over, FEC of the LH ewes rapidly decreased to levels similar to the HH ewes from day_{15} onwards, during most of Period 2. Conversely, FEC of the HL ewes rapidly increased to levels similar to the LL ewes from day_{19} onwards.

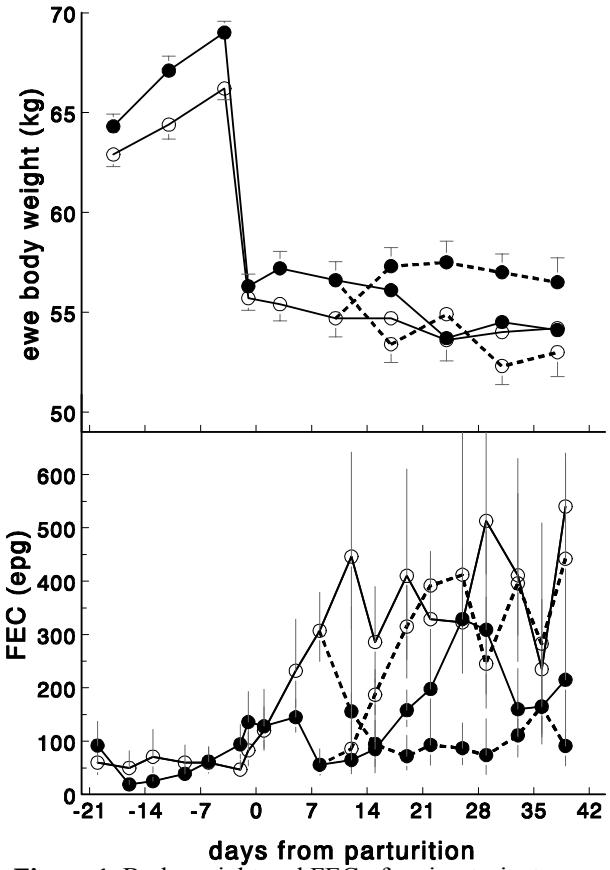

Figure 1. Body weight and FEC of periparturient ewes.
○ and ● (solid line): low and high MP supply throughout, respectively;
○ and ● (dashed line): low and high MP supply from day_{10} onwards, respectively.

Conclusion These results indicate that increased protein supply at times of protein scarcity rapidly improves expression of immunity to abomasal nematodes in lactating sheep. Conversely, a decreased protein supply at times of protein abundance rapidly reduced expression of immunity. The data support the view that nematode egg excretion is relatively sensitive to changes in the degree of MP scarcity. This emphasizes the importance of maintaining improved levels of protein supply to parasitized, periparturient ewes to reduce their contribution to pasture contamination with gastrointestinal nematode parasites.

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The effects of metabolisable protein supply and machine milking on the periparturient relaxation of immunity against *Teladorsagia circumcincta* in dairy ewes

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Introduction Increased anthelmintic resistance worldwide has lead many to investigate alternative methods of parasite control (Donaldson *et al.* 1998). In sheep it is believed that the larval contamination of the pasture is derived mainly from the mature breeding ewe due to the periparturient relaxation of immunity (PPRI). Donaldson et al. (1998) reported that increasing the metabolisable protein (MP) supply of the ewe in late pregnancy may moderate the PPRI. Previous studies investigating the effect of MP supply to dairy ewes on faecal nematode egg output have, however, not shown significant differences (Partington *et al.* 2003). This study investigates the effects of both MP supply and the effect of milking on the PPRI and worm burden.

Material and methods Thirty-two pregnant dairy ewes were fed 1 of 2 dietary treatments and allocated to 1 of 4 groups: Low MP, machine milked (LMP-M), Low MP, lambs suckled (LMP-S), High MP, machine milked (HMP-M) or High MP, lambs suckled (HMP-S), in a 2 x 2 factorial design (n=8), from 6 weeks prior to parturition until week 7 of lactation. The diets offered differed in levels of MP, a low MP diet (0.976 x daily requirement) and a high MP diet (1.75 x daily requirement). From week 6 *pre-partum* all ewes were inoculated with approximately 30,000 *Teladorsagia circumcincta* infective larvae per week. The lambs from the milked ewes were weaned at 72 hours *post-partum* and the ewes machine milked 3 times per day until the end of the experiment (yields recorded and samples collected weekly). The remaining ewes suckled 2 lambs with milk yield being estimated by lamb weight gain. Faecal samples were collected weekly, and blood samples obtained fortnightly. Liveweight and condition scores (CS) were recorded weekly. The ewes were slaughtered in week 7 *post-partum* to determine abomasal worm burdens. The faecal egg counts (FECs) and worm burdens were transformed according to $Log_{10}(n+1)$ prior to statistical analysis using GENSTAT.

Results An increased MP supply significantly lowered ($p<0.001$) ewe FECs *pre-partum* (Table 1). During lactation suckling increased ($p=0.009$) ewe FECs. Ewes that were suckled were calculated to have higher milk yields ($p=0.001$) and higher abomasal worm burdens ($p=0.002$) than the milked ewes. An increased MP supply increased ($p<0.001$) ewe weight gain up to parturition, while during lactation ewes that suckled lost more weight ($p=0.003$) than the milking ewes. Ewes on the high MP diets compared with the low MP treated ewes had lower eosinophil counts ($p=0.065$) and the ewes that were suckled had lower counts than those milked ($p=0.052$). Increased MP supply increased the milk protein concentration (milk ewes only), plasma urea, albumin and total protein concentrations ($p<0.05$) whilst ewes that were suckled had higher ($p=0.015$) plasma total protein concentrations.

Table 1 - The effect of MP & milking method on ewe FECs, worm burdens & performance (transformed data).

	Treatment					Significance		
	LMP-M	LMP-S	HMP-M	HMP-S	S.E.D.	MP	Lambs	Interaction
FEC *prepartum* (epg)	318 (2.32)	213 (2.12)	52 (1.18)	57 (1.34)	(0.34)	***	ns	ns
FEC *postpartum* (epg)	27 (1.20)	223 (2.18)	28 (0.63)	29 (1.04)	(0.34)	ns	**	ns
FEC overall (epg)	125 (1.94)	196 (2.12)	36 (1.02)	44 (1.23)	(0.33)	***	ns	ns
Total worm burdens	240 (0.99)	15728 (3.37)	7144 (1.46)	10608 (3.85)	(1.02)	ns	**	ns
Eosinophils ($x10^9$/l)	1.328	0.890	0.908	0.668	0.24	0.065	0.052	ns
Average milk yield (ml/day)	1610	1957	1599	2496	243.5	ns	**	ns
Milk protein (g/kg)	39.87	-	37.22	-	0.99	*	n/a	n/a
Plasma urea conc. (mmol/l)	5.95	2.93	11.91	11.79	0.77	***	ns	ns
Plasma total protein (g/l)	66.14	68.34	68.07	72.54	1.81	*	*	ns
Plasma albumin (g/l)	27.47	27.31	29.88	31.40	1.08	***	ns	ns
Ewe wt gain *prepartum* (kg)	5.03	5.12	14.02	12.97	2.22	***	ns	ns
Ewe wt change *postpartum*(kg)	2.03	-2.22	1.75	-2.94	1.92	ns	**	ns
Lamb birthweights (kg)	3.39		3.57		0.42	ns	n/a	n/a
Lamb weight gain (g/day)	-	202	-	256	27.5	0.062	n/a	n/a

*Key ns = non significant (P>0.05), *P<0.05, **P<0.01, *** P<0.001.*

Conclusions Increased MP supply reduced FECs both pre-partum and throughout the experimental period and resulted in higher plasma urea levels. Ewes that were suckled had higher milk yields, a greater weight loss and had higher FECs during lactation and higher worm burdens than their milked counterparts. This may explain previous studies which have suggested that increasing MP supply to dairy ewes had no effect on FECs.

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Benefits of yeast culture supplementation on the performance of bull calves

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Introduction The use of direct fed microbials has been shown to enhance digestion in the ruminant. One source of microbial live populations is a yeast culture *Saccharomyces cerevisae* (Yea-Sacc ^{1026}, CBS 493.94; *Alltech Inc, USA*), and its use in ruminants has been associated with a range of benefits including an overall increase in dry matter and fiber digestibility (Wiedmeier and Arambel, 1985), combating heat stress in lactating cows (Huber and Higgenbotham, 1985) and increased performance (Fallon and Harte, 1987). Glade and Biesik (1982) working with yearling horses, demonstrated increased DM and N digestibility when *S. cerevisae* was added to the diet. It was suggested that *S. cerevisae* enhanced cellulolytic activity, triggering microbial metabolism changes in the horse's large intestine that enhance hemicellulose fermentation. They also reported that the addition of *S. cerevisae* results in smaller percentages of absorbed nitrogen excreted in the urine, indicating that the biological value of the *S. cerevisae*-supplemented diets may be more than the direct contribution of the nitrogen within the yeast itself. The aim of this review is to determine the effects of *S. cerevisae* on performance parameters of bulls.

Materials and methods A series of studies conducted in Ireland involved a total of 236 Friesian male calves (age 21 days at the start of the study (50 kg)) that were offered a barley soyabean meal based diet. Treatment animals received *S. cerevisae* (see table 1 for actual concentrations added) and the studies lasted 84 – 168 days. Parameters recorded include feed intake, liveweight gain and feed conversion efficiency. For the meta-analysis, the Shapiro-Wilk test was used and the means for each criterion were analysed separately by a 2-way ANOVA as a randomized block design, with factorial treatment structure comprising treatments and study number. Interactions between treatments and study number were also investigated and the significance threshold for all tests was set at $P<0.10$.

Results

Table 1: Summary of the 3 yeast culture (YC) studies performed with a total of 236 Friesian calves

Study (duration)	YC dose (CFU/kg)	n	DMI/d (kg)	End live-weight (kg)	ADG (kg/d)	FCR
1 (84d)	0	38	1.20^{a}	98.26^{c}	0.63^{c}	1.93
	2 x 10^{8}	38	1.35^{b}	108.16^{d}	0.75^{d}	1.83
2 (168d)	0	20	3.29	240.6^{c}	1.11^{c}	2.97
	2 x 10^{8}	20	3.28	244.3	1.14	2.97
	4 x 10^{8}	20	3.51	255.3^{d}	1.19^{d}	2.94
	8 x 10^{8}	20	3.39	247.3	1.15	2.95
3 (168d)	0	40	2.8	221.42^{e}	1.02^{e}	2.80
	2 x 10^{8}	40	3.1	234.29^{f}	1.1^{f}	2.81

Means with superscripts are significantly different a, b $P<0.001$; c,d $P<0.05$; e,f $P<0.01$

A significant increase in ADG was observed in all 3 studies with the dietary supplementation of *S. cerevisae*. The meta-analysis revealed higher DMI ($P=0.01$; SE 0.13), greater liveweight ($P=0.02$; SE 2.51) and ADG ($P=0.02$; SE 0.02) in those animals receiving the *S. cerevisae*-supplemented diets.

Conclusions Dietary supplementation of *S. cerevisae* increases ADG of calves. This may be a result of increased DMI resulting from changes in rumen fermentation and / or enhanced palatability of the diet. Indeed, Fallon and Harte (1987), reported that irrespective of the type of diet offered, the DM digestibility was increased by 2 percentage units due to the inclusion of *S. cerevisae* ($P=0.08$). The authors also stated that the inclusion *S. cerevisae* in barley / soyabean diets altered rumen fermentation with a resultant increase in rumen pH which in turn stimulated an increase in DM intake. Furthermore, Dawson (1987) reported a 4-6 fold increase in anaerobic bacterial population in the rumen with *S. cerevisae* suggesting that dietary *S. cerevisae* supplementation acts as a fermentation modifier and consequently increases performance in ruminants.

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The effects of molasses inclusion level on the cleanliness and performance of early-weaned Texel cross lambs

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Introduction The production of early-weaned lamb is a high cost production system with the major cost being the concentrate consumed by the lamb. However the transformation of concentrate to weight gain is more efficient when the concentrate is fed to the lamb directly rather than fed to the dam and the lamb avails of the mother's milk. This type of finishing system requires a lamb with a high lean proportion in the carcass, a trait that characterises Texel cross lambs. Molasses, a by-product of the sugar processing industry, is high in soluble carbohydrates and is a common ingredient in commercial animal feed formulations. Inclusion levels in excess of 10% have been reported to cause excessive stickiness of the feed (Ewing, 1997). Molasses based diets increase propionic acid concentrations in sheep (Cortez et al., 1987), which promotes soft carcass fat (Bozzolo et al., 1990). The objective of this experiment was to determine the optimum inclusion rate of molasses in the diet of early-weaned lambs, based on growth rate, lamb cleanliness and carcass characteristics.

Materials and methods Lambs (n=100) were early weaned at 40 days of age when concentrate feed intake reached 250g/day. Two days later they were allocated to one of four treatments, which were balanced for lamb gender and weight, and offered concentrate diets *ad libitum* with different molasses inclusion levels: T1, 0% molasses; T2, 3% molasses; T3, 6% molasses or T4, 9% molasses. The dietary formulation which was mixed on site and the control treatment (T1) was 57% barley, 10% citrus pulp, 10% beet pulp, 20% soya bean meal, and 3% minerals. The diets were formulated to be isonitrogenous and increasing molasses inclusion level in the diet was offset by a reduction in barley and an increase in soya bean content. An additional 1% salt was added to help prevent urinary calculi in male lambs. Lambs were group housed on expanded metal slats. Feed intake, lamb growth rate and overall feed conversion efficiency (F.C.E.) were calculated on a two-weekly basis. Lamb cleanliness score (1=clean white fleece, 4=very heavy soiling of fleece) on the day of slaughter was also recorded. Carcass characteristics including conformation, fat cover (1=extremely thin, 5=over fat), fat colour (1=creamy white, 5= red/brown) and fat hardness (1=solid, 5=very soft) were scored after a 3h chilling period in the abattoir blast chill.

Results Lamb performance data are presented in Table 1. Concentrate intake tended to be lower at the higher molasses inclusion levels. Treatment had no effect on growth rate, conformation, fat cover or fat colour ($P>0.05$). Lambs on the 6% molasses diet had softer fat than either the 0% of the 3% molasses inclusion treatments ($P<0.05$). There was a linear increase in the level of fleece soiling with each increment of molasses inclusion ($P<0.05$).

Table 1 The effects of molasses inclusion level on the performance of early-weaned lambs (LSM± SEM)

Treatment	0% molasses	3% molasses	6% molasses	9% molasses	S.E.M.	Sig.
Total feed intake (kg/day)	85.24	80.27	80.20	74.61		
Growth (g/day)	312	306	308	301	9.7	NS
Food conversion efficiency	3.63:1	3.44:1	3.47:1	3.52:1		
Lamb fleece cleanliness	1.6 [a]	2.3[b]	3.2[c]	3.7[d]	0.15	P<0.001
Carcass conformation score	2.52	2.39	2.49	2.26	0.205	NS
Carcass fat score	3.28	3.27	3.41	3.46	0.149	NS
Carcass fat colour score	2.56	2.60	2.55	2.78	0.126	NS
Carcass fat hardness score	3.19[a]	3.17[a]	3.45[b]	3.21[ab]	0.122	P<0.01

[a,b,c,d] Means within rows with different superscripts are significantly different: NS = not significant.

Conclusions While concentrate intake tended to decrease as molasses level increased, treatment had no effect on growth rate and food conversion efficiency. However, of major practical significance was that as the level of molasses increased the adhesion of faecal material to the fleece of the lamb increased in line. The presentation of clean lambs at slaughter is increasingly demanded by our export slaughter plants aimed at the production of a wholesome product. In a commercial situation, the level of fleece cleanliness at the 6% and 9% molasses levels would not be considered acceptable and would result in the return of most of these lambs by the abattoir personnel to the producer. Consequently, the high inclusion rates of molasses in some commercial formulations is questionable, especially if lambs are going to be reared on an all concentrate diet indoors.

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Effect of supplementary betaine and methionine on weaned pig nutrient utilization and gut development

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Introduction A significant fraction (≈ 50%) of methionine (Met) in the diet of weaned pigs is retained by the portal drained viscera (Stoll, *et al.* 1998). The consequent reduction in extraintestinal availability of Met may compromise piglet performance. Met regeneration in hepatic and renal tissues is achieved through combination of a methyl group from either N^5-methyl-tetrahydrafolate or from betaine (trimethyl-glycine) with the Met derivative homocysteine. Supplementing the diet with betaine might therefore improve extraintestinal Met availability and piglet performance. Furthermore, betaine is an osmolyte and has been shown to stabilize or protect the intestinal epithelial structure of broilers under conditions of intestinal stress (Kettunen, *et al.* 2001). Provision of supplementary betaine in the diet of the newly weaned pig may thus reduce the extent of small intestine (SI) morphological degeneration characteristic of the early post-weaning period. The study reported here was designed to test these hypotheses.

Materials and methods Two hundred and fifty six crossbred piglets (JSR Healthbred) were weaned at a mean age of 22.0 ± 0.23 days (± SEM) and liveweight of 6.6 ± 0.07 kg. At weaning piglets were identified with an ear tag and housed in conventional, fully-slatted, flat-deck pens (1.99m^2) in groups of 8 each balanced for litter origin, weaning weight and gender profiles. Each group was offered a diet (CP 230 g/kg, 16MJ DE/kg, lysine 16 g/kg) containing either 4.0 (L) or 5.1 (H) g met per kg diet and supplemented with either 0.0 (O) or 2.0g (B) of betaine (Betafin S1) per kg of diet. Treatments were thus LO, LB, HO and HB. Daily feed intake (FI) and piglet liveweight on days 7, 14 and 21 following weaning were recorded. On days 6 and 20 following weaning 24 piglets (6 /treatment) were killed to measure intestinal morphology and tensile characteristics. Data were analysed as a 2x2 factorial using the GLM procedures of Minitab 12.2; pairwise comparison of means was performed using the Tukey method.

Results Fortifying the diet with Met improved week 1 and overall feed intake ($P<0.1$ and $P<0.05$ respectively), week 1, 3 and overall growth rate ($P<0.01$, $P<0.05$ and $P<0.01$ respectively) and week 1 FCE ($P<0.01$). In piglets killed on day 6, Met supplementation reduced proximal SI crypt depth ($P<0.1$), increased the energy required for rupture of the proximal SI ($P<0.1$) and enhanced medial SI villus height ($P<0.05$) and muscle depth ($P<0.1$). Supplemental betaine had no significant effect on performance but, in combination with the Met rich diet, enhanced week 1 growth expressed per unit of CP intake ($P<0.1$) and cysteine intake ($P<0.05$), and maintained growth rate per unit of Met intake despite the increased consumption of the diet. Betaine supplementation had no effect on gut measurements to day 6. However, dietary betaine level profoundly affected day 20 SI characteristics (Table 1), the effects being mediated primarily through enhancement of medial SI structure.

Table 1 Effects of betaine supplementation on small intestine (SI) characteristics in piglets 20 days post weaning.

Dietary betaine content:	0.0 g /kg diet	2.0 g /kg diet	SEM	P value
Mean SI villus height (μm)	403	447	13	0.034
Mean SI crypt-villus axis (μm)	646	700	15	0.041
Mean SI muscle depth (μm)	64	76	3.6	0.036
Mean SI tensile strength (kg)	0.70	0.85	0.04	0.023
Mean SI tear distance (mm)	17.7	21.1	0.93	0.031
Mean SI tear energy (kg.mm)	5.08	6.88	0.64	0.079

Conclusions Our results demonstrate that dietary Met level strongly influences immediate post-weaning gut development and overall nursery performance. Deficiency in dietary Met is not compensated for by betaine supplementation, however, betaine does enhance nutrient utilisation during the first week following weaning under conditions of met sufficiency. Furthermore our data indicate that, subsequent to week 1, betaine supplementation significantly improves both morphological and physical measures of SI integrity. In combination these findings imply that the mechanisms by which methionine and betaine improve performance and gut development differ.

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Effect of phase feeding diets declining in digestible Lysine: digestible energy (DE) compared to a single diet throughout the growing-finishing period

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Introduction As pigs mature their requirements for amino acids decline. Phase feeding a series of diets of reducing protein and amino acid content has the potential to increase growth rate and improve feed conversion efficiency because less surplus nitrogen (N) is excreted. In addition, phase feeding is expected to reduce the amount of N excreted in the manure. This experiment was carried out to assess the response of group penned growing-finishing pigs to feeding a single diet throughout or a sequence of five diets of high, medium or low amino acid content.

Materials and methods Four hundred and forty six crossbred pigs (progeny of meatline sires out of F1 LW*LR dams) were used in the study. Initial weight of pigs was 38.3 ± 3.8 (mean ± s.d.) kg. Groups (n=32) of 14 pigs of similar weight were assigned at random to one of four dietary regimes: single diet throughout (SM), high lysine sequence (HL), medium lysine sequence (ML) and low lysine sequence (LL). The trial period consisted of five phases of two weeks each. Digestible lysine: digestible energy (DE) ratio was 0.70 g/MJ throughout for SM, and declined in increments of 0.035 g/MJ for HL (from 0.77 to 0.63 g/MJ), for ML (from 0.70 to 0.55 g/MJ) and for LL (from 0.63 to 0.48 g/MJ). Crude protein ranged from 190 to 130 g/kg and digestible lysine from 10.5 to 6.5 g/kg. Soya bean meal was substituted by barley and wheat (in equal amounts) and soya oil to provide a series of isoenergetic diets (13.7 MJ/kg) declining in digestible lysine: DE ratio. Synthetic amino acids were added to maintain the ratio between digestible lysine:methionine:threonine:tryptophan of at least 1:0.30:0.66:0.20. The pen mean was the experimental unit. Pigs were slaughtered by exsanguination after CO_2 stunning when average pig weight exceeded 95 kg. Backfat and muscle depths were measured 6 cm from the midline of the split carcass midway between the 3rd and 4th last rib using the Hennessy Grading Probe approximately 45 minutes post mortem. Carcass lean meat (LM) was estimated according to the formula: LM (g/kg) $= 534.1 - 7.86*X_1 + 2.66*X_2$ where X_1 and X_2 represent backfat and muscle depths in mm. Margin over feed cost (MOF) was calculated by subtracting the feed cost per pig plus the value of the pig at the start of the experiment from the carcass value at slaughter. MOF of SM was used as a base (100) with MOF of HL, ML and LL expressed relative to this. N excreted was calculated by subtracting N gain (carcass N at slaughter minus carcass N at the start of the experiment) from N intake (protein intake*0.16). Carcass lean at the start was estimated multiplying initial weight by 0.675 and 0.65 (to adjust to carcass weight and lean content of the pig). Carcass lean at slaughter was calculated by multiplying the cold weight by the lean proportion. Carcass N was then estimated by multiplying the carcass lean by 0.22 and 0.16 (protein has 0.16 nitrogen and is 0.22 of lean). Carcass N gain was calculated as carcass N at slaughter minus carcass N at the start of the experiment. Proportion of N retained was estimated by dividing the N gain by the N intake. Statistical analysis was by the GLM procedures of SAS Inc., Cary, N. Carolina for a randomised complete block design. Single degree of freedom contrasts were used to compare the effects of SM against HL, ML and LL.

Results Data is presented in Table 1 for the entire trial period. No differences were observed between SM and HL or ML for growth rate, feed intake, feed conversion ratio (FCR), carcass growth rate or carcass FCR (P>0.05). LL pigs grew slower than SM pigs (P<0.05), but had similar feed intakes (P>0.05), which resulted in poorer FCR (P<0.05). Similarly LL pigs had lower carcass growth rates than SM pigs (P<0.05) and higher carcass FCR (P<0.05). Margins over feed, when compared to the base (SM), increased with HL and ML but decreased with LL, though these effects were not significant (P>0.05). ML and LL pigs excreted less N than SM pigs (P<0.05, P<0.001), who excreted similar quantities to HL pigs (P>0.05). ML and LL pigs retained a higher proportion of consumed N than SM pigs (P<0.001) but HL pigs did not (P>0.05).

Table 1 Effect of treatment on performance results (ls means)

	Treatment					P-values[1]		
	SM	HL	ML	LL	sem	SMvHL	SMvML	SMvLL
Average daily gain, g/d	852	840	860	817	10.7	0.50	0.66	*
Average daily feed intake, g/d	2119	2089	2144	2093	32.9	0.57	0.64	0.62
Feed conversion ratio, kg/kg	2.49	2.49	2.50	2.59	0.03	0.91	0.93	*
Carcass daily gain, g/d	729	713	742	696	9.0	0.28	0.38	*
Carcass FCR, kg/kg	2.91	2.93	2.89	3.01	0.03	0.73	0.70	*
Margin over feed cost	100	106	108	98	5.08	0.48	0.35	0.81
Nitrogen excreted, kg/pig	3.13	3.15	2.81	2.46	0.07	0.83	*	***
Proportion of nitrogen retained	0.24	0.25	0.27	0.28	0.003	0.33	***	***

[1]* P<0.05 *** P<0.001

Conclusions Compared to using a single diet, feeding a sequence of diets declining in digestible lysine: DE ratio improved N retention and reduced N excretion at the ML and LL levels but not at the HL level. However, reducing the digestible lysine: DE ratios to those used in LL had a negative effect on growth and efficiency of pigs.

The effect of dietary energy source on digestibility in growing pigs

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Introduction Cereals have traditionally been used in the pig industry as the main source of energy in pig diets. However, as a result of cereal availability and price, alternative sources of energy have been considered, for example the addition of oil to cereal by-product-based diets. By-product-based diets commonly contain higher levels of fibre than cereal-based diets and several studies (e.g. Bakker *et al* 1995) have reported them to be less digestible in terms of dry matter (DM), energy, crude protein (CP) and oil. The lower DM digestibility of by-product-based diets may lead to a higher level of slurry output, which is an increasing environmental concern. The aim of this work was to examine the differences in digestibility between by-product-based diets supplemented with oil and cereal-based diets.

Materials and methods Seven experimental diets were formulated; A (control diet), B (diet A + 19g/kg vegetable oil blend (VOB)), C (diet A + 38g/kg VOB), D (diet A + 58g/kg VOB), E (diet A + 76g/kg VOB), F and G. Half of the total amount of oil added to each diet was incorporated into the pellet and the remainder was sprayed on after pelleting. The control diet (A) consisted of g/kg; 250 barley, 160 wheat, 65 maize germ, 50 maize gluten, 50 maize gluten feed, 150 wheat pollard, 75 rapeseed, 163 soya 50, 32 binder, 5 minerals and vitamins. Diet F consisted of g/kg: 456 barley, 250 wheat, 247 soya 50, 42 binder, 5 minerals and vitamins. Diet G consisted of g/kg: 249 barley, 326 wheat, 150 barley, 227 soya 50, 10 herring, 33 binder, 5 minerals and vitamins. Fourteen male crossbred (Large White x Landrace) pigs were randomised to the seven diets in a three period partially balanced crossover design. Each of the seven treatments was replicated six times. Each period comprised a 7 day pre-feed and a 7 day faecal collection period and pigs were housed in metabolism crates. Feed was offered at 900, 1200 and 1500g/d in periods I, II and III respectively. Samples of the diets and faeces were collected and analysed to determine digestibility of DM, CP, oil, neutral detergent fibre (NDF), and energy. Dietary digestible energy content (DE) was also determined and the results were analysed by ANOVA using Genstat 5 (1993). The formulated DE values of the diets were (MJ/kg); A=12.5, B=13.0, C=13.4, D=13.8, E=14.3, F=13.1 and G=13.5.

Results Digestibility coefficients for DM, energy, CP and NDF were higher (9, 9, 6.5 and 22% respectively) for diets F and G than for diets A to E (Table 1). Digestibility of oil in diets B to E was higher (16%) than for diets F and G which can be simply attributed to the higher level of oil in diets B to E. There were no significant differences between diets F and G in terms of digestibility but diet G contained a higher level of DE. There were no significant differences in the digestibility of diets B to E. However, digestibility of all parameters tended to be lower for diet A than for diets B to E. The actual DE content (Table 1) of the by-product diets (A to E) were lower (2%) than the formulated values and the actual values for diets F and G were higher (2%) than the formulated values.

Table 1 Digestibility and DE content of experimental diets

	A	B	C	D	E	F	G	s.e.m.	P
DM digestibility	0.76^{a}	0.78^{ab}	0.78^{b}	0.78^{ab}	0.78^{ab}	0.84^{c}	0.86^{c}	0.007	<0.001
CP digestibility	0.78^{a}	0.80^{a}	0.79^{a}	0.79^{a}	0.80^{a}	0.83^{b}	0.85^{b}	0.008	<0.001
Oil digestibility	0.69^{b}	0.76^{c}	0.78^{c}	0.80^{c}	0.76^{c}	0.64^{a}	0.66^{ab}	0.014	<0.001
NDF digestibility	0.48^{a}	0.52^{ab}	0.54^{b}	0.52^{ab}	0.54^{b}	0.62^{c}	0.65^{c}	0.016	<0.001
Energy digestibility	0.76^{a}	0.78^{ab}	0.78^{b}	0.78^{ab}	0.78^{ab}	0.84^{c}	0.86^{c}	0.007	<0.001
DE (MJ/kg DM)	14.0^{a}	15.1^{b}	15.1^{b}	15.4^{bc}	15.7^{c}	15.2^{b}	15.7^{c}	0.14	<0.001

Means with the same superscript are not significantly different

Conclusions Although DM digestibility of the control diet was lower than for diets F and G, the addition of oil produced diets of similar DE values and hence is a feasible means of improving the energy concentration of more fibrous diets. Nevertheless, the higher DM digestibility of the cereal based diets (F and G) may be important in reducing the slurry output from pig units. CP digestibility was lower for diet A than for diets F and G which is in keeping with previous studies (Bakker *et al* 1995) and can be attributed to increased microbial fermentation as a result of higher levels of dietary fibre. In contrast to Jorgensen and Fernandez (2000), the addition of oil to the control diet did not improve protein digestibility. Although the discrepancies between formulated and determined DE values were relatively small, the combined effect (i.e. apparent overestimation of oil and underestimation of cereal) may be important in commercial situations.

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The effect of dietary nucleotide supplementation on immune status of post-weaned pigs

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Introduction The post-weaning growth check causes considerable economic losses in pig production. Some of the problems in susceptibility to disease have been associated with immunoregulation. For example, immaturity of the neonatal immune system, stress-associated and pathogen-induced immunosuppression have all been linked to increased disease susceptibility throughout the early post-weaning period. Studies in both infants and animal models suggest that dietary nucleotides have significant effects on the immune and gastrointestinal systems (see Carver, 1999). It has been suggested that under conditions of limited nucleotide intake, rapid growth or certain disease challenges, dietary (or pre-formed) nucleotides may spare the cost of *de novo* nucleotide synthesis and optimise the metabolic function of rapidly dividing tissues such as those of the gastrointestinal and immune systems. The aims of the current study were to determine the effects of a yeast-based nucleotide source (Ascogen™; *Chemoforma Ltd, Switzerland*) on performance, gut physiology, microflora and immunological parameters in post-weaned piglets.

Materials and methods Thirty-six entire male piglets (of initial live weight 14.9 kg and weaned at 28 ± 1 days of age) were used. Diets were based upon identical formulations (typical commercial diet for the post-weaned piglet) but diet 2 was supplemented with 4 g / kg of the yeast-based nucleotide. Animals were offered experimental diets from 14 days pre-weaning. At weaning, the animals were transferred to the experimental unit, individually housed and 4 piglets were slaughtered on day 0 (weaning day) to provide baseline data, and 8 piglets were subsequently slaughtered on days 2, 4, 6 and 14. The animals received the same diets pre- and post-weaning and each of the 2 diets was fed to 16 piglets over an experimental period of 14 days. At slaughter, samples of the small intestine were taken for histological examination, and digesta samples were also removed for pH and microbiological enumeration for lactobacilli, coliforms, *E.coli* and bifidobacteria species. A peripheral blood sample was removed for subsequent lymphocyte isolation and proliferation studies in response to the mitogen phytohaemaglutinin (PHA; figure 1). The statistical model was a diet * day factorial (using POLYANOVA generating linear and non-linear contrasts within Genstat V)

Results

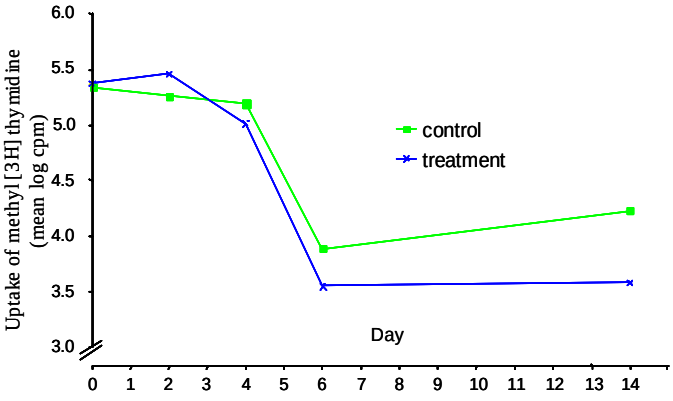

Figure 1. Uptake of methyl thymidine by lymphocytes in response to 10µg/ml PHA.

A significant temporal response was observed ($P<0.001$; s.e.d 0.12), together with significant interactions between diet and day ($P=0.021$; 0.010(L); s.e.d 0.16). No significant effects of dietary treatment alone were observed.

No significant dietary responses were observed in terms of gut physiology (villus height, villus width, crypt depth), microbiology or performance parameters. The animals offered the nucleotide-supplemented diet did, however, exhibit reduced intestinal pH (mean 6.7 vs 7.0, $P=0.009$), compared with control animals.

Conclusions Previous data generated in the programme suggest that the introduction of creep feed from 14 days pre-weaning may exert a beneficial influence on the gut ecosystem (in terms of stabilisation of the microflora). When levels of intake are sufficient (English, 1980, suggested 600g/d), creep feeding pre-weaning allows a period of adaptation to occur to the diets before the stressful event of weaning occurs. Although those animals offered the treatment diets displayed more alkaline digesta pH values, any effects of this were not manifest on the gut microbial populations investigated. The lymphocyte proliferative responses may indicate that the animals were experiencing some degree of hypersensitivity reaction in response to the dietary antigens, although there is also some suggestion that the observed response is age-dependent. Previous experiments conducted at Nottingham (Pickard and Wiseman, 2002) demonstrated a significant reduction in intestinal coliform load with dietary nucleotide-supplementation. It is therefore suggested that the introduction of dietary treatments from 14 days pre-weaning allowed an adaptation period, thus minimising negative effects on gut structure and microflora which are commonly associated with weaning.

Acknowledgements Meat and Livestock Commission**,** Provimi Ltd.

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Relationships between leucocyte subsets, performance, diet and bacterial load in Large White cross Landrace pigs

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Introduction The exposure of pigs to different pathogens compromises productivity (Greiner *et al*., 2000), i.e. reduces weight gain and food intake, even in the absence of clinical disease. Associations between productivity and a range of immunological traits have been demonstrated in apparently healthy animals facing the same infectious challenge (Clapperton *et al*., 2003). Specifically, it was demonstrated that some leucocyte proportions (monocytes, B cells, MIL-4 (NK) positive cells) increased significantly as performance decreased. This study aims to verify these previous results on an independent population of pigs, examine relationships between immune measures and actual bacterial counts in the gut, and examine the influence of diet type on these measurements.

Materials and method 90 Large White x Landrace pigs, 43 male, 47 female, were studied as a sub-population during a standard performance test from about 34kg to 103kg at slaughter (see Thompson *et al.* 2004). At the start and mid test (week 6), the proportions of mononuclear cell sub-sets positive for CD4, CD8, NK, gamma delta, B cell and monocyte marker were calculated on peripheral blood samples (Clapperton *et al*., 2003). At slaughter micro-organisms were enumerated from the ileum, caecum and colon into the categories shown in Table 3 (see Hillman *et al*., 2004), and log10-transformed counts were averaged across the three measurement sites. All measured traits were analysed using Residual Maximum Likelihood (REML) techniques, fitting the fixed effects of sex, room, bedding type and diet. Associations between immune measures and daily growth rate were quantified by multiple regression analysis, after fitting the fixed effects described above, with the immune measures as dependent variables. Correlations were calculated between microbial counts and immune measurements to investigate relationships between these traits.

Results Diet had a significant effect on the leucocyte subset proportions measured: the proportions of gamma delta and CD8+ cells were increased and NK cells and monocytes significantly decreased on the liquid diet (Table 1). Microbial counts and performance were likewise both significantly improved on the liquid diet (Hillman *et al*., 2004, Thompson *et al*., 2004). Leucocyte proportions measured at the start of test were weakly predictive of subsequent performance (Table 2) with all significant relationships being negative, i.e. performance declines as the cell type increases. Correlations between immune measurements and microbial counts (Table 3) were consistent across the type of micro-organism and generally reflected the treatment effects on the leucocyte subset proportions. 'Total' is the sum of all micro-organisms.

Table 1 Effect of diet upon mid-test leucocyte subset proportions (x100)

Subset	Mean	S.D.	Dry	Liquid	Diff.	s.e.(diff)
Gamma delta	28.3	7.39	24.7	31.7	7.03**	1.61
CD4+	17.8	2.84	17.5	18.4	0.88	0.62
CD8+	33.4	7.55	31.5	35.9	4.47**	1.65
NK (total)	17.4	4.92	20.1	14.7	-5.41**	1.08
B cells	9.8	3.62	10.0	9.85	-0.15	0.79
Monocyte†	14.5	0.58	3.89	3.50	-0.39**	0.13

† Diet effects calculated using square root transformed data;**p<0.01

Table 2 Regressions (g/day/proportion) of weight gain on start-of-test immune traits.

Trait	regression,*p<.05	s.e.
Gamma delta	-8.24*	3.40
CD4+	2.12	6.10
CD8+	-2.52	2.71
NK (total)	-6.05	3.93
B cells	1.85	4.77
Monocytes	-7.02*	3.35

Table 3 Correlations between leucocyte proportions and microbial counts;* p<0.05.

	Coliform	Lactobacilli	Anaerobes	Aerobes	Yeast	Total
Gamma delta	-0.40*	-0.35*	-0.40*	-0.33*	-0.22*	-0.44*
CD4+	0.00	-0.02	-0.01	0.04	-0.09	-0.03
CD8+	0.13	0.03	0.00	-0.14	0.22	0.09
NK (total)	0.31*	0.29*	0.30*	0.26*	0.15	0.34*
B cells	0.14	0.12	0.16	0.18	0.00	0.15
Monocytes	0.14	0.16	0.17	0.13	0.17	0.20

Conclusion The predicted negative relationship between performance and immune measurements was seen, but only at the start of test. Mid-test immune measures were strongly affected by diet, and this was consistent with similar effects on performance and bacterial load, and also consistent with correlations between the immune measures and microbial counts. Thus the data is consistent with the hypothesis that differences in immune measurements are indicative of differences in health and infection status.

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Modelling the effects of social stressors on the food intake and performance of growing pigs

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Introduction The performance of commercial pigs is often below that seen under good experimental conditions. At least some of this decrease in performance can be attributed to environmental stressors. Stressors in the physical environment have been modelled (e.g., Black et al., 1986) allowing predictions of performance under varying conditions to be made. However, the influence of social stressors, including group size (N), space allowance (SPA, $m^2/BW^{0.67}$), feeder space allowance (FSA, feeder spaces/pig), and mixing, on pig performance, although undeniable, is generally ignored in pig growth modelling. The aim here was to quantify the effects of the major social stressors on the performance of growing pigs. Genetic variation in the ability to cope, and the social stressor effects were integrated to produce a more general growth model.

Materials and methods The effects of the main social stressors, N, SPA, FSA and mixing, on the intake and gain of growing pigs were described by conceptual equations derived on biological grounds. Parameter values were estimated from experimental data in the literature. It was assumed that social stress decreases the capacity of the animal to attain its potential. This is equivalent to lowering the maximum rate of daily gain (ADG_p, kg/d). As it is assumed that animals eat to attain their potential, a decrease in ADG_p necessarily leads to a decrease in intake. Genetic variation between breeds in their ability to cope with social stressors is represented by an extra genetic parameter in the model (EX). The value of EX adjusts both the intensity of stressor at which the animal becomes effectively stressed, and the extent to which stress reduces performance and increases energy expenditure (activity) at a given stressor intensity. The chosen functional forms were integrated into the general growth model of Wellock et al. (2003) as mechanistic equations in a logical way. This allowed the effects of interactions that exist between social stressors and other variables, such as pig genotype, feed composition and the physical environment on intake and growth, to be explored and, at least in principle, predicted. The model was used to simulate some relevant experiments with social stressors as the main variables.

Results The effects of N and SPA on the predicted time taken to grow from 20 to 50 kg are shown in Figure 1. As N increased and SPA decreased, the predicted time to reach 50 kg increased. An increase in N from one to 100 increased the time taken to reach 50 kg by nine days from 40 to 49 at a SPA of 0.5 m^2/pig, whereas at 0.3 m^2/pig the time taken was increased by 10 days from 43 to 53. Figure 2 shows the effects of EX (0, 5 or 10) on the average daily gain (ADG, kg/d) of pigs with two levels of potential performance, 'intermediate' (ADG_p = 0.85 kg/d) and 'good' (ADG_p = 1.07kg/d), from 20 to 80 kg with N between one and 100. As N increased, ADG was predicted to decrease for both genotypes, with pigs with the poorest ability to cope (EX = 10) showing the largest decrease. With N > 25, the intermediate pigs with low values of EX (EX = 0) were predicted to outperform the good pigs with high values for EX (EX = 10), having greater daily gains and intakes and reaching 80 kg two days earlier.

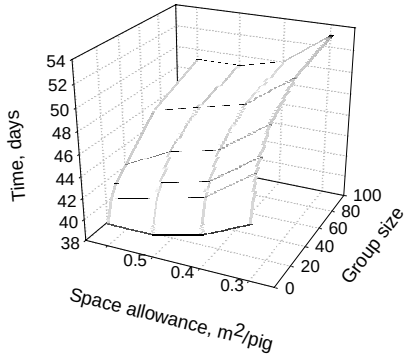

Figure 1. Effect of space allowance and group size on the time taken for pigs to grow from 20 to 50 kg

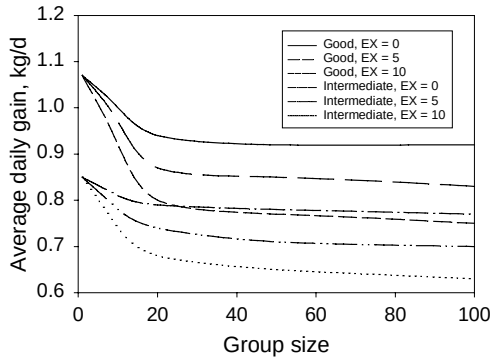

Figure 2. The effect of group size, pig potential (intermediate and good) and EX (0, 5 or 10) on the average daily gain of pigs grown from 20 to 80 kg

Conclusion The adapted model described here is an initial attempt at quantifying and predicting the effects of the major social stressors on the intake and gain of pigs differing in both genetic potential for growth and in ability to cope when raised under given dietary, physical and social environmental conditions. Quantifying social stressor effects may allow the removal of constraints that prevent pigs achieving their potential and increase the profitability of pig enterprises.

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Predicting the performance of populations of growing pigs

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Introduction Models intended to simulate animal performance typically represent a single animal. The assumption necessarily made is that the response of the population will be the same as that of the deterministically simulated response of the 'average' individual. However, this will necessarily be the case only if all animals in the population have an equal growth potential, all are at the same stage of growth and all react in the same way to encountered stressors. In order to predict adequately the response of a population in a given environment it is necessary to take account of between animal variation. The objective of this work was to investigate the impact of between-animal variation on the predicted performance of a population of growing pigs.

Materials and Methods The model of Wellock et al. (2003) that predicts the effect of the social, physical and nutritional environments on pig performance was extended to deal with a population. Variation in initial state was created by generating variation in initial body weight (BW_0) from which the chemical composition of the pig is calculated. Variation in growth potential was created by generating variation in the genetic descriptors of the pig and variation in ability to cope when exposed to social stressors was achieved by generating variation in the parameter EX. The value of EX adjusts the intensity of stressor at which the animal becomes effectively stressed, and the extent to which performance is reduced and energy expenditure increased at a given stressor intensity. It is expected that within a population or group that the social environment, e.g., position within the social hierarchy, affects an individuals ability to cope. Consequently, it was assumed in the model that the larger, more dominant individuals within a population are better able to cope (e.g., Drickamer et al., 1999). For each simulated pig within a population, values for the genetic growth descriptors were drawn at random around the population mean from uncorrelated normal distributions. Individual values for BW_0 and EX were generated from their respective means and standard deviations (model inputs) whilst taking into account the generated growth descriptors of the individual. This ensures that bigger pigs tend to have increased growth potential and a better ability to cope. The model was used to simulate some relevant experimental conditions with environmental stressors as the experimental factors. Firstly, the mean response of the population to environmental stressors was predicted and compared with that of the response of the average individual. Secondly, the effect of within population variation in EX (σEX) and BW_0 (σBW_0, kg) on the performance of growing pigs to a given slaughter weight (BW_f, kg) and over a given time period (t, days) was predicted.

Results The type of stressor determined whether the mean population response to a given stressor was the same as the average individual response. If all pigs in a group were affected at the same stressor intensity, e.g., all are either mixed or not, then the predicted average individual and mean population responses were the same. If however, the intensity of stressor at which performance becomes limiting differed between individuals, such as critical space allowance or upper critical temperature, then differences between the individual and mean population responses were predicted. Whilst no differences between the average pig and mean population were predicted in response to mixing, there may be large differences between individuals of a population (Figure 1). As σBW_0 and σEX increased, variation in both t (set BW_f simulations) and BW_f (set t simulations) increased, whilst the mean population responses remain unchanged. For example, as σBW_0 was increased from 0 to 10 kg the variation in time (σt, days) taken to reach BW_f increased from 3.93 to 14.23 days and the variation in BW_f (σBW_f, kg) over the set period of 50 days increased from 2.85 to 11.02 kg. Daily gain, feed intake and body composition were not affected by increasing either σBW_0 or σEX.

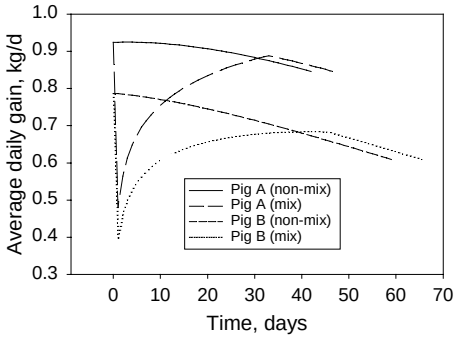

Figure 1. Effect of mixing on the average daily gain of two individuals (60 to 100 kg)

Conclusion Proper allowance for population variation may be important when models are used to predict nutrient requirements, optimise pig production systems and devise animal breeding strategies as there may be differences between the response of the individual and the mean population due to between-animal variation. The variation in the growth response of a population was determined to a greater extent by variation in BW_0 and EX than by variation in growth potential when pigs were simulated in conditions likely to be encountered in commercial environments. This is an important practical consideration in commercial pig production where the heterogeneity of the population at slaughter may affect the profitability of an enterprise. Consequently, decreasing the variation in initial state and improving pig's ability to cope when exposed to stressors may be a better way of improving pig performance and enterprise profitability than selecting only for increased growth potential.

Acknowledgements This work was supported by BBSRC and SEERAD.

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A system for 3D imaging of pig shape for conformation assessment

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Introduction The 3D shape of live animals plays an important role in achieving good husbandry and in selecting breeding stock. Many shape features are subtle and cannot be extracted from 2D images. With 3D data, it would be possible to extract cross-sectional areas and volumes, and to measure features such as the squareness of the back muscles, which are known indicators of lean muscle mass (Whittemore 1998). However, there is currently no simple method to measure 3D shape in live animals. In this work a system has been developed for freezing the motion of a pig using flash photography and processing the images to extract the 3D surface shape. The imaging system is based on stereo photogrammetry. Three stereo pods, each consisting of two digital cameras, were set up at perpendicular directions in order to cover the whole of a cuboidal imaging volume. The imaging volume dimensions were 1300 mm long × 900 mm high × 700 mm deep. The imaging system was calibrated prior to capturing the pig images. Multi-resolution correlation-based stereo matching (Siebert and Urquhart, 1994) was used to establish correspondences between the left and right images in each stereo pair. The output of the stereo matching of each pod was a 2.5D range image. These range images were integrated into a 3D model.

Material and methods An imaging trial was carried out using two groups of 16 pigs. The groups were fed *ad-lib*, one on a high lysine diet, and the other on a low lysine diet, in order to induce shape differences due to differing growth rate and fat-to-lean ratio. The trial lasted for 14 weeks, during which the pigs grew from an average weight of 30 kg to 80 kg. The pigs were weighed and images were captured at weekly intervals. The complete data set contained two images per pig per week, spanning shape changes due to growth, diet group and individual variation. In addition, there were some sessions in which large numbers of images were captured, with the pig in different positions, in order to collect data on shape changes due to posture. The images were stored in a 120 GB database.

Results The accuracy of the surface depth recovery was assessed using a test object. This consisted of two sheets of aluminium glued together so as to form a flat 500 × 500 mm square, with a flat 100 × 100 mm square depression in the centre. The imaging system could measure depth differences very accurately, and could reconstruct a flat object with a r.m.s. deviation of better than ±0.1 mm. Figure 1 shows the 3D model of one pig as a highlighted surface. It is captured as a 3D mesh of about 16,000 nodes. Further work is in progress to develop means of classifying the surface shape. Differential geometry (Jain et al, 1995) has been used to classify the 3D curvature of a pig surface, revealing anatomical details which are not normally apparent to the human eye. Figure 2 shows the curvature classification as a colour-code and a set of surface landmarks (crosses) which were placed manually on features related to the underlying muscle structure.

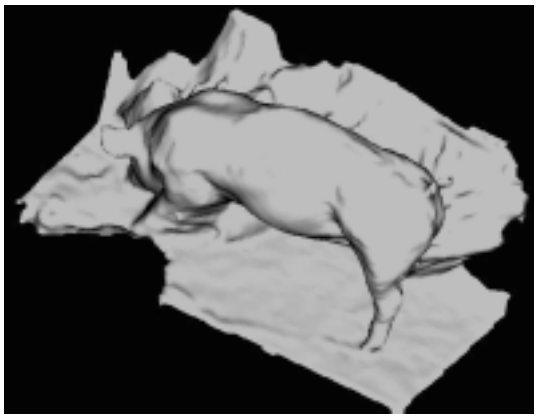

Figure1 Surface recovery from a live pig

Figure 2 A curvature classified surface with landmarks

Conclusions A 3D multi-view stereo imaging system was developed which successfully captured the 3D shape of live pigs. The accuracy of surface recovery was assessed as an r.m.s. error of better than ±0.1 mm on a test object. Results showing recovered 3D models of live pigs have been presented. The imaging system has been used to collect shape data for 32 pigs weekly during a 14 week growth trial.

Acknowledgements This work was funded by the Biotechnology and Biological Sciences Research Council.

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Real-time control of pig growth through an integrated management system (IMS)

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Introduction Integrated management systems (IMS) for pigs offer the prospects of optimising meat production and minimising nitrogenous pollution through closed-loop control of pig growth by nutritional control (Whittemore, *et al.*, 2001). Such an IMS requires a real-time sensor system, a nutritional model which is optimised in response to data collected in by the sensor system, and a control system which uses forward predictions of the model to predict the nutritional regime required to satisfy growth and pollution targets. An experiment was carried out to determine the accuracy to which a novel IMS system can direct pig weight gain and fatness towards preset targets through nutritional control.

Materials and methods A total of 144 pigs of a commercial breed were reared in controlled environment facilities in twelve pens. Pigs were fed *ad libitum* diets that varied in crude protein (CP) content between pens, produced by blending two source diets of 140 and 190 g / kg CP. Live weight estimated by a visual image analysis (VIA) system (Marchant and Schofield, 1999) and feed intakes were recorded for individual pigs on a daily basis. Manual weights and P2 back fat depth measurements were also taken. The system was based on the model described by Green and Whittemore (2003). From the daily live weight and intake data, two model parameters (one controlling efficiency of use of dietary supplied nutrients, the other maximum protein retention rate) were optimised for each pig using the Revised Simplex Method (Nelder and Mead, 1965). The same algorithm was used to control dietary CP content for each pen, reappraised weekly, according to the following growth targets (two pens for each target): a) 50 kg and b) 60 kg weight gain; and c) 12 mm and d) 16 mm final P2 back fat depth. The final two pairs of pens were fed on the two extreme CP levels throughout.

Results Model optimisation results are given in Table 1. Optimising the parameters using VIA data for the first 39 days, or for the whole growth period, resulted in a good model fit without bias. In addition, prediction to the end of the trial using parameters estimated from the data for the first 39 days produced good model predictions. RMSEP values were within the range of measurement error of live weight by VIA. The system controlled the average weight in three out of four pens to within 3 kg of the target; in the fourth, a change in growth rate at the end of the trial resulted in a deviation of -5.8 kg (Table 2). For fat depth, control produced results close to the lower target of 12 mm. The achievement of the higher target lay beyond the capability of the system given the range of possible diets and *ad libitum* feeding, but these pens achieved the highest P2 fat depth in the trial.

Table 1 Observed and modelled live weight (kg). Root mean squared errors of predictions (RMSEP) are given in parentheses

Observed weight	Model weight – unoptimised	Model weight - optimised
Optimisation to day 39		
74.0	70.0	73.2
Optimisation to day 39, prediction to end		
96.5	90.3 (8.4)	97.0 (6.3)
Optimisation to end of trial		
		96.8 (5.0)

Table 2 Growth targets for each pen, with mean final deviation from target. Standard errors are given in parentheses

Target		Deviation
Weight gain (kg)	49.3	2.1 (2.4)
	49.3	2.3 (0.9)
	59.1	-5.8 (1.5)
	59.1	2.0 (2.4)
Final P2 back fat depth (mm)	12	-0.9 (0.53)
	12	0.2 (0.60)
	16	-2.1 (0.72)
	16	-2.4 (0.68)

Conclusions The present study has shown that pig growth model optimisation can be performed in real time using VIA data, and that weight gain in pigs can be controlled through an integrated management system using *ad libitum* feeding and a range of diet CP content. Some control of fat depth may also be possible.

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Testing new selection indices for sustainable hill sheep production - lamb performance traits

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Introduction Hill sheep breeds are required to survive and rear lambs in harsh conditions, and good maternal characteristics contribute to their success. However, improved carcass characteristics are also required to meet market requirements. This paper evaluates lamb performance characteristics after 4 years of selection using indexes tailored to improve overall productivity in different hill sheep production systems.

Material and methods Two selection indexes were derived using genetic parameters for carcass and maternal characteristics from Conington *et al*. (2001) and economic values from Conington *et al*. (2004). The selection index for lamb producers and finishers (farm 1) includes economic weightings for maternal traits as well as carcass weight, fat and conformation grades, whereas the index for store lamb producers (farm 2) only includes economic values for maternal traits and lamb growth to weaning. Three selection lines of Scottish Blackface sheep per farm were created with the first lambs born to each line in 1999. These lines were selection (S), control (C) and industry (I). Five top- and 5 average-performing ram lambs were selected each year for the S and C lines respectively using a multi-trait BLUP implementation of the indexes. The I line used 4 mature rams bought from industry, selected on appearance only, i.e. adherence to breed 'type'. For both farms, all three lines were managed together as one flock. Ewes already on the farms rotated between the three lines until they left the flock at the end of their normal lifespan, but females born within a line remained in that line. Responses to 4 years of selection were evaluated for index score, lamb weights and slaughter characteristics. Least squares means for the genetic lines were calculated by residual maximum likelihood (REML) techniques in Genstat, accounting for the effects of age of dam, grazing paddock or area, birth/rearing type, sex and age at weaning (covariate). Traits measured at slaughter were compared at a constant carcass fat class, which was transformed to estimated subcutaneous fat proportions (ESF%), i.e. 1=0.04, 2=0.08, 3L=0.11, 3H=0.13, 4L=0.15, 4H=0.17 and 5=0.20 (Kempster *et al*., 1986).

Results The S line tended to have higher index scores than the C or I lines although to date, no significant differences are seen between the lines. The index scores (and standard deviations) in 2002 at farm 1 were 79.7 (373.0), 90.16 (233.5) and 472.9 (277.3) and at farm 2 were 8.7 (115.3), -7.16 (127.9) and 153.4 (137.9) for C, I and S lines, respectively. On farm 1, S line lambs were generally significantly heavier ($p<0.05$) than the C and I line lambs (Table 1), and received a significantly higher price per carcass. On farm 2 only birth weight differed significantly between lines.

Table 1 Lamb performance data for 2002-born lambs: least square means (and average s.e.d.) according to genetic line and farm.

	Farm 1				Farm 2			
	C	I	S	s.e.d.	C	I	S	s.e.d.
Live weights (kg) at:		n=828				n=591		
Birth	3.68	3.74	3.76	0.119	3.33 ^{ab}	3.18^{a}	3.43^{b}	0.089
Mid lactation	16.43 ^{a†}	16.87 ^{ab}	17.55 ^{b}	0.475	15.84	15.74	16.14	0.345
Weaning	26.44 ^{a}	27.94 ^{ab}	28.97 ^{b}	0.909	24.19	24.27	24.96	0.503
Slaughter	40.30 ^{a}	40.16 ^{a}	42.85 ^{b}	0.603	33.95	33.36	33.53	0.884
Condition score	2.95	2.96	2.94	0.021	3.00	2.99	2.98	0.023
Carcass traits		n=367				n=240		
Carcass weight (kg)	18.85 ^{a}	18.49 ^{a}	19.66 ^{b}	0.284	14.99	14.90	14.90	0.419
Conformation (E=5)	2.85	2.94	2.79	0.104	2.41	2.40	2.53	0.113
Age at slaughter (days)	241.5	237.8	241.1	3.581	190.7	188.8	189.3	8.04
Price per carcass (£)	41.64 ^{a}	40.79 ^{a}	43.67 ^{b}	0.743	30.08	30.11	29.86	1.178

†Least squares means with different superscripts differ significantly ($p<0.05$).

Conclusions The selection indexes have altered lamb growth rate in expected directions, but the divergence between the S and C lines is only significant for the less harsh farm environment (farm 1). The index used on farm 2 would benefit sellers of store lambs but not buyers or finishers of these lambs, as the tendency for lamb weights to be heavier at weaning was not evident at slaughter. Economic gains are expected from the lamb carcasses at farm 1 and, to a lesser extent, from the sale of store lambs at farm 2. The unfavourable correlated response in birth weight at farm 2 may lead to future modification of the index if this trend continues. Further work to evaluate the impact that selection has had on maternal characteristics is necessary.

Acknowledgements We are grateful to SEERAD, Defra, BWMB and MLC for funding parts of this work.

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A non-linear index to select genetically lean sheep with sufficient fat cover

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Introduction Generally, selection indices used for the selection of livestock are linear combinations of estimated breeding values (EBVs), with each EBV weighted according to its marginal or relative economic value. This approach can be extended to non linear combinations. In both cases knowledge of economic weights is required. When economic values are not known, one can determine the relative weights that lead to the desired genetic progress. This approach was taken by Simm and Dingwall (1989) when designing the lean index for British terminal sire breeds. A weighting of +3 for lean in the carcase and -1 for fat in the carcase leads to near-maximum increase in lean, while maintaining amount of fat. This index has been highly effective over the last decade (MLC, 2002) to the extent that in recent years breeders have expressed concerns that offspring from high index ram have insufficient fat cover at slaughter. The current study aims to design an index that is broadly similar to the lean index, but puts a penalty on animals with a genetic merit for low fat cover.

Ultrasonic fat depth (FD) is the best indicator of fat cover in the live animal and its EBV can be used in selection against lack of cover. In a linear index, FD EBV would have a positive relative economic value. The consequence would be selection for animals with high FD, which is not desirable. An alternative is independent culling of animals having a FD EBV below a certain threshold. Independent culling is inferior to a selection index with regard to genetic progress and in a practical situation with annual updates of EBVs would lead to awkward situations with a huge impact of slight changes in the FD EBV around the threshold. It is therefore desirable to use a continuous function that puts a weight of 0 on FD EBV for most animals, but a high positive weight on FD EBV for very low FD EBVs. Such a function can be designed using an arc tangent. The weight on FD EBV then is:

$$\text{weight(FD EBV)} = (0.5 - \text{arc tangent}(b*(\text{FD EBV} - a))/\pi)*c$$

with a determining the point of inflection, b the slope and c the magnitude of the positive weight, and the

$$\text{index} = 3 * \text{lean in carcase} - 1 * \text{fat in carcase} + \text{weight(FD EBV)} * (\text{FD EBV} - a)$$

Material and methods The effect of the arc tangent index was investigated in the last three lamb crops (2001-03) born in the Charollais, Meatlinc, Suffolk and Texel Sire Reference Schemes and compared to the existing index and independent culling on FD EBV. The analyses used the actual EBVs as calculated in the multitrait BLUP run of 2003. Indices were calculated as described above and standardised to an average of 100 and standard deviation of 40 in the base year (1990, 1991 or 1992 depending on the breed). The top 10% and top 25% were selected on various alternative indices, and evaluated on their genetic merit in terms of the current lean index as well as their ability to exclude animals with a FD EBV below the threshold.

Results Various values for a, b and c were investigated and it was concluded that the optimum values for Meatlinc, Suffolk and Texel were a=0.1, b=10, c=15. For Charollais, a=-0.4 gave better results. Figure 1 shows the weighting on FD EBV and the contribution to the index sheep using the optimal function for Texel. Table 1 presents the percent of animals with a FD EBV below 0 for two breeds, comparing the current and alternative index and the loss in index expressed in current index points.

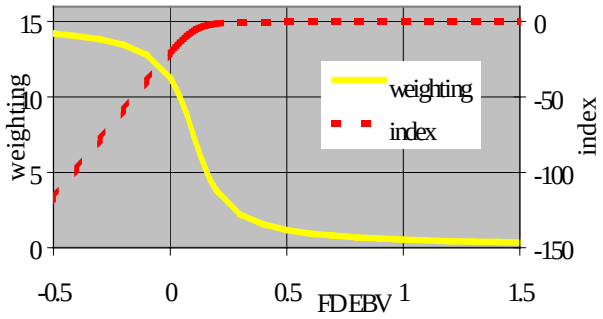

Figure1 Weighting on FD EBV and contribution to index

Table 1 Percentage of top animals with FD EBV< 0 (current and new index) and reduction in lean index

		% FD EBV < 0		change in
breed	top	current	new index	index (%)
SF	10%	31	2	-3.5
	25%	31	3	-4.4
TX	10%	58	3	-7.6
	25%	53	6	-8.3

Conclusions A non-linear index was designed that selects lean terminal sire sheep without compromising fat cover. The loss in genetic merit for lean in selected sheep is relatively small, and will be more than compensated by less use of independent culling as well as increased uptake and penetration of performance recording.

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Prediction of UK dairy fertility proofs for foreign bulls

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Introduction We have recently developed a Fertility Index for UK dairy cattle (Wall *et al.*, 2003). After examining national data it was decided that the Fertility Index should be based on sire PTAs for calving interval (CI) and non-return rate (NR) after 56 days weighted by their relative economic weights. However, just under half of the available bulls have no milking daughters in the UK. It would take about 4 years from the time of first use in the UK, for a bull to have sufficient daughters for a reliable fertility proof. Waiting this long for fertility information on which to base selection decisions will slow genetic progress and is undesirable as many of these bulls could have fertility proofs in their country of first test. This study examines the feasibility of converting foreign fertility proofs to UK equivalents.

Materials and methods Files were received from countries publishing fertility proofs; Ireland, The Netherlands, France, Germany, Denmark, New Zealand, Australia and the United States and these files were matched to the UK records based on the international ID of a bull. A number of restrictions were used on the data from common bulls to ensure their suitability for the derivation of conversion equations. First and second crop daughters of AI bulls were extracted. In the majority of cases minimum birth year was set at 1990. Reliability of the fertility proof from each country was at least 50% in all cases. Conversion methodologies were based on INTERBULL guidelines (Philipsson *et al.*, 1986) following methods described by Goddard (1985). First proofs in the importing country (UK) were "deregressed" and the deregressed proof (P_B') were regressed on the proof in country A (P_A), the exporting country to yield the appropriate regression coefficients. The approximate precision of the conversions was measured by calculating the correlation of the actual UK proofs and those predicted from foreign proofs.

Results The correlations between the predicted and actual UK fertility proofs and counts of common bulls after edits are given in Table 1. The Dutch fertility index (FI) is derived from breeding values for NR and calving to first service interval (CFI) and the FI is described in terms of CI. The correlations between actual and predicted UK CI and NR were 0.71and 0.65 respectively, based on conversions from Dutch FI and NR. The Danish FI is derived from weighted breeding values for NR, 1st to last insemination interval and CFI. The correlation between actual and predicted UK CI PTAs was 0.51, using the Danish FI. Daughter pregnancy rate (DPR) in the US measures the percentage of non-pregnant cows that become pregnant during each 21-day opportunity period. There was a correlation of 0.76 between actual and predicted CI (Figure 1).

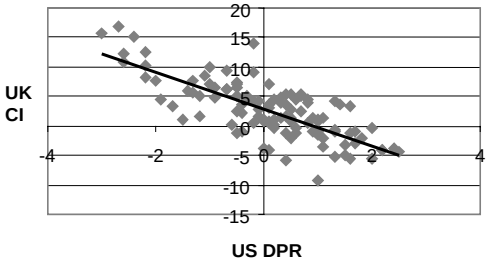

Figure 1 Plot of UK CI (deregressed) and USA DPR with linear regression line

Table 1 Count of common bulls (no.) and correlations (r) between actual and predicted UK proofs.

	r	no.
	UK CI	
IRL CI	0.69	68
US DPR	0.76	108
NLD FI	0.71	46
NZL FI	0.51	43
DNK FI	0.51	103
AUS CI	0.73	65
	UK NR	
NLD NR	0.65	46
FRA FI	0.58	47
DEU NR	0.39	64

Conclusions Conversion equations have been successfully developed for the UK for a number of foreign countries' fertility proofs. Data were available from the main countries trading semen with the UK. A notable exception is Canada who have not developed a fertility index as yet. The differences in the fertility traits evaluated and the model used in each country limited the accuracy of conversions. An example would be the inclusion of service sire information in the German model for NR or the choice of fertility traits in New Zealand. If component trait proofs were available, as opposed to combined fertility indices, conversions could be more precise. Conversions of foreign proofs were applied where possible and over 85% of the available UK bulls had either domestic or partially converted fertility proofs. Correlations between fertility proofs in the UK and other countries were moderate to high. Another option to the conversion of individual country proofs would be the development of an international evaluation service for fertility traits. Experience from this and similar studies suggests that a multiple trait multiple across country evaluation (MACE) may be more suitable for fertility traits and this approach will be strongly recommended.

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Test day model evaluations of production traits in the United Kingdom (UK)

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Introduction The test day model (TDM) has become the method of choice for genetic evaluation of production traits in dairy cattle. However, in the UK, complete test day (TD) records are only available from 1995 compared with 305d yields utilised in the current animal model (IAM) dating back to 1975. The analysis of TD records only would significantly reduce accuracy of evaluations through limited data including loss of dam information on cows with records prior to 1995. An optimum solution would be the joint analysis of TD and 305d records. This paper presents a TDM used for the joint analysis of TD and lactation records in the UK and results from its application to the Holstein Friesian (HOL), Jersey (JER) and Guernsey (GUE) breeds.

Materials and method A multiple trait multi-lactation reduced rank random regression TDM has been fitted to analyse milk, fat and protein yields in the first three parities as different traits (Mrode et. al, 2003). The model for the i^{th} parity consisted of the fixed effects of herd-test-day (htd), month pregnant by stage of lactation, days open, lactation curves nested within age by season effects and heterosis and recombination (HOL only). The random animal and permanent environmental (pe) effects in the i^{th} parity were each modelled by 6 random regression (RR) coefficients. The 6 RR coefficients for the random animal effect represented the 6 largest eigenvalues from a genetic covariance matrix of order 9 estimated by fitting Legendre polynomials of order 2 for each trait in the i^{th} parity. Similarly, the 6 RR for the pe effects were from the 6 largest eigenvalues from an eigenvalue decomposition of the covariance matrix for pe. The covariables corresponding to the RR coefficients either for the animal or pe effect were obtained from the eigenfunctions corresponding to the 6 largest eigenvalues. The same model was fitted for the 305d records except that herd-year-season was fitted in place of htd and the covariables for animal and pe effects and residual variances were accumulated over 10 standardised stages of lactation assuming monthly sampling. The software, Mix99 (Lidauer, et al, 1999) was used to solve the equations. After convergence, Predicted Transmitting Abilities (PTAs) for lactations 1-3 were computed from the RR coefficients for animal effects. The PTAs were averaged across parity for each bull and cow and compared with those from the current IAM. Persistency PTAs indicating the bulls genetic ability for milk yield at 280 days in milk compared to day 60, expressed as a proportion, were computed.

Results The correlations of bull PTAs between the TDM and the IAM were high at about 0.97 for milk, fat and protein for JER and HOL bulls (Table 1) with a reliability of at least 0.50 in the IAM. Similar correlations for GUE were slightly lower, varying from 0.92 to 0.94. The correlations increased for JER and HOL bulls to about 0.99 when the reliability was raised to ≥ 0.90, indicating very little average change in PTAs for bulls with large number of daughters.

Table 1 Correlations between bull and cow yield PTAs from the TDM and IAM

	Holstein					Jersey				Guernsey			
	N	Rel	Milk	Fat	Prot	N	Milk	Fat	Prot	N	Milk	Fat	Prot
Bulls	22066	≥ 0.50	0.97	0.97	0.98	1203	0.97	0.97	0.97	936	0.92	0.94	0.94
	4359	≥ 0.90	0.99	0.98	0.99	176	0.99	0.99	0.98	118	0.96	0.97	0.97
Cows	4782125	≥ 0.30	0.95	0.95	0.96	123736	0.93	0.94	0.92	84151	0.82	0.85	0.87
	241893	≥ 0.65	0.92	0.93	0.94	4386	0.93	0.93	0.89	1953	0.85	0.88	0.89

Correlations between cow PTAs from the TDM and IAM were about 0.95 for HOL, 0.93 for JER and 0.85 for GUE for all cows with reliability of ≥ 0.30 in the IAM. Considering cows with reliabilities higher than 0.65, the correlations dropped slightly for HOL and JER but increased for GUE (Table 1). The average persistency PTAs across three parities expressed as a proportion were 0.51, 0.51 and 0.49 for HOL, JER and GUE bulls respectively. For bulls with Milk PTAs more than 100kg higher on the TDM than the IAM, average persistencies as a ratio of the respective breed means were 1.04:1 for HOL, 1.01:1 for JER and 1.07:1 for GUE. Conversely, for bulls with milk PTAs lower by 100 kg in the TDM relative to the IAM, average persistencies as a ratio of the respective breed means were 0.996:1 for HOL, 0.96:1 for JER and 0.93:1 for GUE. Thus some of the differences in bull PTAs between the TDM and IAM could be explained in terms of the TDMs ability to account appropriately for the persistency of bull daughters.

Conclusion The joint analysis of TD and 305d records is feasible and overcomes the problems of blending results from 2 different models. Correlations of less than unity implies the introduction of TDM would result in changes for cows and bulls with limited numbers of daughters. New persistency PTAs will help explain some of the changes.

Acknowledgement Genetic parameters used for the study were estimated by R. Thompson, I. White and S. Brotherstone. Their help in developing the model is also acknowledged.

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Beef breeding decision support system in the UK

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Introduction The UK beef industry has over recent years seen a decline in the quantity and quality of heifers available as replacements to the suckler herd. Historically the dairy industry supplied the beef suckler herd with surplus dairy cross beef heifers. However, with the Holstenisation of the UK dairy herd and a reduction in size of the national dairy herd beef farmers are looking towards alternative replacement strategies. Many breeds of cattle are available for use in UK beef production and many different combinations of breeds can be used in crossbreeding scenarios. Tools have been developed recently to identify the best individuals from the most appropriate breeds to be used in the optimum breeding strategy. To identify appropriate breeds for specific production functions required quantification of performance traits for the breeds of cattle used commercially. At an enterprise level a deterministic bioeconomic model BREEDS (Beef Replacement Enterprise Evaluation Decisions Support) was developed (Roughsedge *et al.*, 2003) to evaluate changes in breeds and breeding systems. The model simulates all aspects of beef production including the transition of the breed composition, over generations, as well as biological and economic performance of animals within the herd, over time. Breed performance parameters used in BREEDS were derived by combining results of a meta-analysis of published breed comparison experiments (Roughsedge *et al.*, 2001) with performance data collected on cattle in Britain by MLC Signet, including aspects of maternal performance. Once appropriate breeds are identified breeding values will help to identify the best individuals to use. This study outlines the traits considered for maternal estimated breeding values (EBVs) to allow breeders to improve maternal aspects of breed performance and commercial producers to select bulls appropriate to their replacement breeding needs.

Materials and methods Proposed new EBVs include lifespan (LS), calving interval from first to second calving (CI1), calving success 365 days after first calving (CSu1), age at first calving (AF) and mature weight (MW), in addition to maternal genetic weaning weight (W200m), which is already available. For the LS trait a predicted value was assigned to censored records. The AF trait considered age at first calving as an opportunity with a binary score, 0 or 1, indicating an early or late calving age for the herd given the herd first calving age distribution. For example if a herd-year has animals calving at 2 and 3 years old, scores are assigned as a 0 to a 2 and a 1 to a 3 year old calving. If a herd has only three year old first calvings the records are treated as missing. Two new indexes have been developed to quantify the effect of the new EBVs on cow feeding costs and general maternal ability. Genetic parameters for obtaining EBVs have been estimated with a linear sire maternal grandsire model using ASREML (Gilmour *et al.*, 2002). Heritabilities of new traits and their genetic correlation with other new and existing traits have been estimated.

Results Parameters, including weight at 400 days (W400), are presented as a weighted mean from Limousin, Angus, South Devon and Simmental estimates in Table 1. Low to moderate estimates of heritability for these traits suggests that selection progress is possible in this area of production. Initial construction of the proposed new indexes suggest that to get reliable estimates of maternal ability bulls will need to have recorded daughters. This implies that mature bulls will be used as proven replacement breeding bulls in contrast to the young performance tested bulls used as terminal sires.

Conclusions Software implementing the BREEDS model has demonstrated that maternal production has a high contribution to profitability. Reproductive rate and puberty attainment are especially important. For example, in a system utilising terminal sires for matings in excess of replacement needs the proportion of these matings made falls with both reduced reproductive rates and late attainment of puberty. This has the effect of lowering the overall beef quality of the calves produced in addition to increasing the cost of replacements. These traits are an important element of the maternal selection goal.

Table 1. Heritability and genetic correlation estimates (s.e.) for maternal traits using UK Limousin, Angus, South Devon and Simmental data.

Trait	MW	AF	CI1	LS	W200m	W400
MW	0.31	0.10	-0.14	-0.52	-0.39	0.85
	(0.05)	(0.12)	(0.23)	(0.19)	(0.25)	(0.09)
AF		0.17	-0.10	0.24	0.0	0.11
		(0.03)	(0.11)	(0.10)	(0.16)	(0.11)
CI1			0.08	-0.85	-0.66	-0.21
			(0.03)	(0.07)	(0.40)	(0.18)
LS				0.09	0.30	-0.06
				(0.02)	(0.18)	(0.13)
W200m					0.14	-0.66
					(0.02)	(0.07)
W400						0.38
						(0.03)

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An update to the UK national profit index £PLI

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Introduction The profit index currently used in the UK was designed in 1992 to combine production and longevity in an optimal manner. There have been no enhancements to this index for some years but during this period the industry has suffered wide-scale disruptions as a consequence of BSE and foot and mouth disease. The quality of data on reasons for culling has reduced, putting greater emphasis on prediction of longevity from type traits, and other issues relating to animal management have risen in priority. Increasing the emphasis on welfare associated traits such as lifespan and health in a widely used selection index will lead to both increased health and welfare of dairy cows and increased public confidence in dairy farming. The objectives of this project were to (1) enhance the prediction of lifespan by incorporating farmer-friendly composite type traits (2) re-evaluate economic weights of traits in £PLI to account for changes in costs/returns and (3) enhance £PLI by the addition of health traits (somatic cell count and lameness).

Materials and methods Traits were analysed in groups of 4 using an animal model with pedigree. There were 55,226 Holstein-Friesian cows with production (milk (M), fat (F) and protein (P), somatic cell counts (SCC), type and lifespan (LS) observations and 109,017 animals in the pedigree file. The model used to estimate genetic parameters for the production traits and SCC included age and month of calving and herd-year of calving. The model for type traits included age and stage of lactation at inspection, month of calving and herd-visit. Lifespan, in lactations, was modeled in a similar way to the production traits but the milk yield of the cow, as a deviation from the herd mean yield, was included as an additional covariate. A dynamic programming model was used to derive economic values for production, lifespan, mastitis and lameness, using up-to-date assumptions for milk prices, culling costs, replacement costs etc.

Results Genetic correlations between fore udder attachment (FUA), legs & feet composite (L&F), mammary composite (MAM), locomotion (LOC), production, SCC and lifespan are given in table 1. Heritabilities are on the diagonal.

Table 1. Genetic correlations and heritabilities.

	LS	FUA	L&F	MAM	LOC	M	F	P	SCC
LS	0.028	0.255	0.504	0.259	0.254	X	X	X	-0.241
FUA		0.229	0.155	0.630	0.166	X	X	X	-0.153
L&F			0.179	0.447	0.979	X	X	X	0.014
MAM				0.315	0.208	X	X	X	-0.009
LOC					0.105	0.031	0.129	0.110	-0.048
M						0.470	0.621		0.193
F							0.391		0.145
P								0.428	0.129
SCC									0.135

Assuming an average cost of clinical mastitis of £81 per affected lactation, the economic value of mastitis was estimated at £0.83 per % incidence. Similarly, assuming a treatment cost for lameness of £97 per lactation, the economic value of lameness was estimated at £0.99 per % incidence.

Conclusions Based on these genetic correlations, and keeping in mind the intention to use locomotion to predict lameness, the traits chosen to best predict lifespan were fore udder attachment, legs and feet composite, mammary composite and SCC. The accuracy of prediction was 0.53. A new £PLI was derived which uses both legs and feet and mammary composites to predict lifespan and includes SCC as a predictor of mastitis and locomotion as a predictor of lameness. In this index, 78.7% of profit is from production and 21.3% from health and longevity. The new £PLI is:

-0.04 x Milk PTA + 1.05 x Fat PTA + 2.94 x Protein PTA + 32 x Lifespan PTA
-0.20 x SCC PTA + 1.28 x Locomotion Proof

Selection on this index in the UK will increase fat and protein content, prolong lifespan and reduce mastitis and lameness in dairy cows.

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Models that challenge the existence of a negative correlation between direct and maternal genetic effects on 200 day weight for beef cattle

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Introduction A calf's weight at weaning is influenced not only by its own genes for growth (direct genetic effects) but also its mother's genes for maternal (milking) ability. Selection for genetic improvement in both maternal ability and growth are an important part of current breeding programmes for many beef breeds. Estimated breeding values for both components are obtained by separating the direct and maternal effects on live weights around weaning by fitting appropriate statistical models. Many previous studies have estimated large negative genetic correlations between the direct and maternal components (r_{AM}) of a round -0.5 (Meyer, 1997). Whether these estimates are a true reflection of the actual biological relationships have frequently been questioned. Meyer (1997) showed that by fitting additional random terms in the model [i.e. sire or sire*year environmental terms, dam-offspring environmental covariance/correlation (r_{AeDe})] the magnitude of the negative r_{AM} estimates could be reduced. The aims of this study were: (i) to estimate the magnitude of the r_{AM} in a UK population, (ii) to investigate the relative importance of various additional terms, and (iii) to test the importance of including a non-zero r_{AM} in these alternative models.

Materials and methods Live weights at 200 days of age were available for 43435 Aberdeen Angus calves that had been recorded between 1965 and 2002 as part of the MLC/Signet genetic recording service. Calculation of the 200 day weight was by within animal linear regression using two or more records taken between the ages of 170 and 300 days. Genetic parameters were estimated using the ASREML package (Gilmour *et al.,* 2002). The base model included, fixed effects of contemporary group, birth month, birth type, breed of mother at weaning, proportion pure (4 classes), linear and quadratic regressions on dam age (days), and random effects of animal, dam (maternal) and permanent environment (p.e.). Pedigree relationships between all animals were also fitted. Additional random effects fitted in turn were, sire, sire*year and r_{AeDe}. The improvements in model fit (models 2, 3 and 4 *versus* 1) were tested by comparing twice the difference in log-likelihoods against a χ^2 distribution with 1 degree of freedom.

Results Under the base model (1), a large negative r_{AM} was estimated (Table 1). Fitting a dam-offspring environmental correlation did not improve the fit of the model and had little effect on the estimate of r_{AM}. However, fitting an additional sire and particularly a sire*year interaction resulted in substantial improvements in fit. In each case the standard error for the r_{AM} estimates were high and its exclusion did not result in a poorer fit. Adding either of the two 'new' terms had little effect on the c^2 estimate but reductions in both the direct and maternal genetic components were evident, with changes being greatest for the heritability estimate which reduced from 0.24 to around 0.08.

Table 1. Parameter estimates (s.e.) for all the models fitted

Model	h^2 †	m^2	c^2	s^2	syr^2	r_{AM}	r_{AeDe}	Vp	Δ logL
1	0.24	0.11	0.12	-	-	-0.53		847.4	-
	(0.02)	(0.02)	(0.01)			(0.05)			
2	0.24	0.11	0.13	-	-	-0.54	0.02	846.4	0 ^{ns}
	(0.02)	(0.02)	(0.01)			(0.06)	(0.04)		
2a	0.17	0.05	0.12	-	-	-	-0.08	840.1	2
	(0.02)	(0.01)	(0.01)				(0.04)		
3	0.07	0.05	0.12	0.06		0.21	-	852.7	48***
	(0.03)	(0.01)	(0.01)	(0.01)		(0.32)			
3a	0.08	0.06	0.12	0.05	-	-	-	853.2	48
	(0.02)	(0.01)	(0.01)	(0.01)					
4	0.10	0.07	0.12	-	0.07	-0.16	-	856.9	91***
	(0.02)	(0.01)	(0.01)		(0.01)	(0.13)			
4a	0.09	0.06	0.12	-	0.07	-	-	856.3	90
	(0.01)	(0.01)	(0.01)		(0.01)				

† h^2, m^2, c^2, s^2, syr^2 are direct additive, maternal, p.e., sire, sire*year variances respectively, expressed as a proportion of the phenotypic variance. r_{AM} and r_{AeDe} are the direct-maternal genetic and dam-offspring environmental correlations respectively. Vp is the phenotypic variance and Δ logL is the change in log-likelihood relative to fitting model 1. ^{ns} and *** indicate the significance level of the change in log-likelihood value from that for model 1.

Conclusions When a sire or sire*year interaction was fitted in the model for 200 day weight for the Aberdeen Angus breed the estimate for r_{AM} was not significantly different from zero, and its exclusion from the model was not detrimental to the fit. Fitting one of these 'new' terms also takes account of environmentally derived variances that otherwise are attributed to direct and maternal genetic sources.

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Evaluation of genetic approaches for controlling microparasite infections in livestock populations by genetic epidemiological modelling

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Introduction There is considerable research efforts aimed towards detecting disease resistance genes or QTL. If found and used in breeding programmes, such genes should reduce the likelihood and severity of epidemics. A critical question is which genes should be used and what will their impact be? Genetic epidemiological modeling techniques (MacKenzie and Bishop, 2001) can give insights into how we should prioritise the prospective resistance traits, hence candidate genes or QTL corresponding to these traits, for specific diseases. Here, a stochastic genetic epidemiological model is used to investigate the relative importance of different genetic control options and the effect of host genetic heterogeneity in controlling the transmission of a microparasitic, e.g. viral or bacterial, infection.

Materials and methods The transmission of microparasitic infection may be described by compartmental models (Anderson and May, 1992), implemented here using a stochastic modelling approach (MacKenzie and Bishop, 2001). A population of 1000 pigs of the same age was simulated. The parameter space investigated was: transmission coefficient (β) (1, 5, 10, 50, 70 and 100 $\times 10^{-5}$ infections/pig^2/day); latent period (1, 2, 7, 15, 30 and 180 days), recovery period (1, 2, 5, 10, 20 and 30 days), mortality rate (0.00**,** 0.02, 0.05, 0.10, 0.20 and 0.30 deaths/pig/day) and loss of immunity period (7, 15, 30, 60, 120, 180 days). Values in bold describe transmissible gastroenteritis (TGE), a highly contagious enteric viral disease of pig for which published parameter estimates are available. Two genetic models were assumed. First, the population was homogenous for each parameter (i.e. trait), and outcomes from varying each parameter whilst holding the others constant were investigated. Secondly, the impact of genetic variation in β, a proxy for resistance to infection, was investigated for the case of three genotypes, *viz.* one locus with two additive alleles (frequencies of 0.5) in Hardy-Weinberg equilibrium. The β for heterozygous genotype was the same as in the homogeneous population, with the two homozygous genotypes being 50% lower and 50% higher, respectively. Total 5000 replicates were run for each scenario and output included probabilities of no epidemic (p), minor and major epidemics (major, if >10% individuals infected and epidemic continued for more than 6 months), maximum epidemic severity (y_{max}) and time of y_{max}. The basic reproductive ratio (R_0) was estimated as (1/p) – 1.0.

Results As β was decreased, the probability of a major epidemic reduced considerably, and the estimates of R_0 corresponded proportionally to values of β (Table 1). For low β values, the effects of variation in other parameters on infection dynamics were small and hence β appears to be the most critical parameter. Within a fixed β, estimates of R_0 and y_{max} increased as the latent period decreased and recovery period increased (results not shown). R_0 also decreased with increased mortality rate, because high mortality rates lead to elimination of the infected animals from the population and thereby reduce disease incidence. Hence the impact of mortality may be considered equivalent to the impact of culling. R_0 showed no appreciable change for large changes in the period of loss of immunity. Results from the comparison of homogeneous and heterogeneous populations were very similar (Table 1), demonstrating that R_0 in a population heterogeneous for β is the weighted average of the outcomes in the constituent sub-populations.

Table 1 Epidemic outcomes and parameter estimates from homogeneous and heterogeneous populations for varied β values, with other parameters held constant at TGE parameter values

$\beta \times (10^{-5})$	Probability of epidemic type			Estimates		
	No epidemic	Minor epidemic	Major epidemic	R_0	y_{max}	Time of y_{max}
Homogeneous Population						
1	0.893	0.107	0.000	0.12	0.000	0.0
5	0.632	0.368	0.0001	0.58	0.021	125.9
10	0.473	0.276	0.250	1.11	0.056	155.4
50	0.197	0.026	0.777	4.08	0.512	33.7
70	0.169	0.012	0.819	4.92	0.578	26.4
100	0.147	0.011	0.842	5.80	0.629	20.8
Heterogeneous Population						
0.5/1.0/1.5	0.894	0.106	0.000	0.12	0.000	0.0
2.5/5.0/7.5	0.629	0.371	0.000	0.59	0.000	0.0
5/10/15	0.491	0.265	0.244	1.04	0.055	153.0
25/50/75	0.197	0.026	0.777	4.08	0.483	34.1
35/70/105	0.155	0.012	0.833	5.45	0.550	26.8
50/100/150	0.139	0.010	0.851	6.19	0.605	21.3

Conclusions Critical parameters influencing epidemic outcomes were the transmission coefficient, essentially host resistance to infection, the latent period and the recovery rate. Increasing resistance, the latent period or recovery rate will reduce the transmission of infection, hence the incidence of disease. The similarity of the homogeneous and heterogeneous results indicates that susceptible animals can be maintained without exposing the population as a whole to undue risk. By equating measured traits to model parameters, the greatest utility of these modelling techniques will be for evaluating the impact of actual disease resistance genes or QTL in terms of helping to reduce disease impact.

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Influences of genetic variance in phenotypic variability on response to artificial selection

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Introduction In standard models of the genetic basis of quantitative traits such as growth rate and milk yield, it is assumed that genotypes differ in their effect on the mean but not on the variance. There is much evidence of differences in variability among environments, and more limited but quite conclusive evidence of differences in residual variability among genotypes (e.g. CanCristobal-Gaudy *et al.*, 1998; Sorensen and Waagepetersen, 2003). Differences among genotypes at an individual locus in their residual phenotypic variation or in the environmental variation among whole genotypes may influence rates of genetic progress and rates of change in variability. We propose models and quantify such changes for directional selection (see also Hill, 2002; Hill and Zhang, 2004).

Materials and methods At the individual locus level, genotypes at an additive locus are assumed to differ both in mean and residual (approximately phenotypic) variance, e.g. $A_1A_1 \approx N(a, V_P + b)$, $A_2A_2 \approx N(-a, V_P - b)$. If selection is of high intensity, individuals of more variable phenotype are more likely to be selected, and the consequent change in the frequency of A_1 is $\Delta q = (ia/\sqrt{V_P} + \frac{1}{2}ixb/V_P)q(1-q)$, where i is the selection intensity and x the truncation point on the standardised scale. For proportion selected p = 0.50, 0.10, 0.01, i = 0.80, 1.75, 2.66 and $\frac{1}{2}ix$ = 0.00, 1.12, 3.12, respectively.

In a multi-locus infinitesimal model, the effects of genes on mean and variance are assumed to be additive over loci. In the first generation from an unselected population, the expected rates of change are $\Delta M = iV_{Am}/\sqrt{V_P} + \frac{1}{2}ixcov_{Amv}/V_P$ and $\Delta V_E = icov_{Amv}/\sqrt{V_P} + \frac{1}{2}ixV_{Av}/V_P$, where V_{Am} is the additive genetic variance in average effects of genes on the mean (terms in a^2 at individual loci, i.e. the usual additive genetic variance), V_{Av} the equivalent variance on variance (terms in b^2), and cov_{Amv} the covariance of effects (terms in ab). Selection also induces covariances in frequencies among loci (the Bulmer effect); for example at generation t+1 in terms of generations 0 and t, V_{Am} is given by
$V_{Am,t+1} = \frac{1}{2}V_{Am,0} + \frac{1}{2}[V_{Am,t} - i(i-x)(V_{Am,t}/\sqrt{V_{Pt}} + \frac{1}{2}ixcov_{Amv,t}/V_{Pt})^2 - i(V_{Am,t}\,cov_{Amv,t})/\sqrt{V_{Pt}}^3 - (3/4)ix(cov_{Amv,t}{}^2/V_{Pt}{}^2)]$,
which reduces to the usual form when $cov_{Amv} = 0$. Similar messy equations describe changes in V_{Av} and cov_{Amv}.

Some examples are given for directional selection and the infinitesimal model in the Table, showing predicted changes in parameters for 10% selected. Initial parameters (in bold in the Table) are: V_{Am} = 0.5, cov_{Amv} = 0, ±0.0625, V_{Av} = 0, 0.125, V_E =1. This shows that, when cov_{Amv} and V_{Av} are non-zero, non-trivial changes in variance and heritability can arise, and asymptotic values of the variances are not reached, even in an infinitely large population.

t	$\Delta\mu$	ΔV_E	V_{Am}	cov_{Amv}	V_{Av}	V_P	h^2	$\Delta\mu$	ΔV_E	V_{Am}	cov_{Amv}	V_{Av}	V_P	h^2
0	0.00	0.00	0.50	0.00	0.00	1.50	0.33	0.00	0.00	0.50	0.06	0.12	1.50	0.33
1	0.72	0.00	0.43	0.00	0.00	1.43	0.30	0.76	0.18	0.40	0.02	0.11	1.59	0.26
2	1.35	0.00	0.41	0.00	0.00	1.41	0.29	1.34	0.30	0.40	0.02	0.11	1.70	0.24
4	2.56	0.00	0.40	0.00	0.00	1.40	0.29	2.45	0.50	0.41	0.02	0.11	1.91	0.21
8	4.95	0.00	0.40	0.00	0.00	1.40	0.29	4.53	0.90	0.42	0.03	0.11	2.32	0.18
0	0.00	0.00	0.50	0.00	0.12	1.50	0.33	0.00	0.00	0.50	-0.06	0.12	1.50	0.33
1	0.72	0.09	0.43	-0.02	0.12	1.52	0.28	0.67	0.00	0.45	-0.08	0.12	1.46	0.31
2	1.31	0.15	0.42	-0.03	0.12	1.57	0.27	1.27	-0.01	0.44	-0.08	0.12	1.43	0.31
4	2.45	0.24	0.42	-0.03	0.12	1.66	0.26	2.44	-0.05	0.44	-0.08	0.12	1.39	0.32
8	4.65	0.41	0.43	-0.02	0.12	1.84	0.23	4.82	-0.14	0.44	-0.08	0.12	1.30	0.34

Conclusion The previous analysis applies to individual selection. If selection is within families, similar selection pressure is put on heterogeneity; but if selection is on a family mean of size n in an index or BLUP, the effects are much weaker, because the offspring means of A_1A_1 and A_2A_2 individuals are expected to differ by a in mean and b/n in variance. As yet information on the magnitude of the quantities cov_{Amv} and V_{Av} is limited, but it should be possible to get information, for example by analysis of variation among large half sib families in their within-family variance.

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Inbreeding trends and application of optimised selection in the UK Holstein population

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Introduction Widespread international use of AI and best linear unbiased prediction (BLUP) breeding values for milk yield has increased genetic gain in many dairy populations, including the UK. The proliferation of few sires through AI and the coselection of relatives favoured by BLUP has however increased the relatedness and inbreeding of the UK population. Inbreeding is undesirable for a number of reasons and it is important to monitor the rate at which it accumulates. Currently, the level and rates of inbreeding (ΔF) are not routinely reported for UK dairy cattle. Optimised selection procedures that maximise genetic gain while constraining ΔF to a pre-defined level have been shown to control ΔF and increase genetic gain over truncation selection at the same ΔF (e.g. Avendaño et al. 2003). The objective of this study was to determine the current rates of inbreeding and to assess the potential of using optimised selection procedures in the UK dairy population.

Materials and Methods Pedigrees were extracted from the Holstein UK database. Inbreeding coefficients (F) were calculated using the algorithm of Meuwissen and Luo (1992) for 330,037 males and 7,029,545 females born from 1940 to 2002. The database includes all imported males and females with progeny in the UK. Mean F was calculated for year of birth of animals. Rates of inbreeding were calculated by regressing F on year of birth. For optimised selection, candidates were chosen according to a generation interval of 6 and 7 years for females (1995-2000) and males (1994-2000) respectively. Breeding values for optimised selection were for production (£PIN) and production plus longevity (£PLI). Due to computing limitations the top 757 males and 5243 females were included in the optimisation. All candidates were required to have at least four generations of complete pedigree. Optimal contributions were calculated using the method of Grundy et al. (1998). Four levels of ΔF were investigated.

Results Average inbreeding has increased sharply since 1992 at a rate of 0.17% per year (Figure 1). This compares to a ΔF of just 0.03% from 1968 to 1991 with no increase prior to 1968. Currently, the average inbreeding is 2.6% for females and 3.1% for males. The sharp rise since 1992 coincides with a large increase in % Holstein (Figure 1). During this time the relationship among the top paternal grandsires also increased sharply (not shown). Results for optimised selection are in Table 1. At the same level of constraint less animals were required when selecting on £PLI than £PIN. In general, as ΔF was reduced the number of selected candidates required to achieve the constraint increased with little loss in genetic gain except for large values of ΔF. For example, optimised selection at ΔF = 0.05% realised a 70% reduction in the rate of inbreeding and achieved 98% of the genetic gain when using optimised selection at the current rate of inbreeding. Optimised selection might be most useful when the selecting parents of future progeny test bulls.

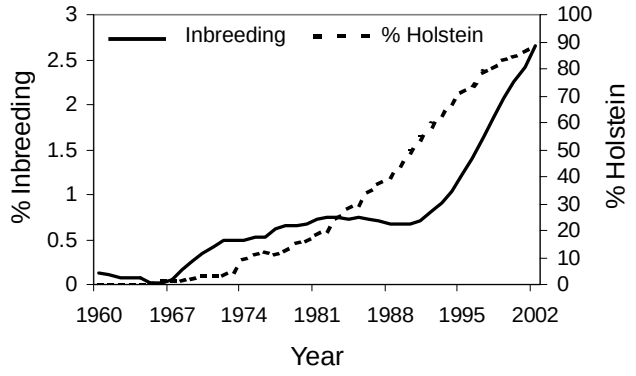

Figure 1 Trend of inbreeding and % Holstein

Table 1 Number of animals selected and expected £PLI and £PIN for optimised selection

	£PLI			£PIN		
ΔF (%)	Males	Females	£	Males	Females	£
0.05	72	88	77.4	74	90	76.5
0.1	71	82	78.2	70	88	77.4
0.17*	69	78	79.3	70	83	78.5
1.0	56	58	90.3	55	67	89.5

* Current rate of inbreeding

Conclusions The rate of inbreeding has increased substantially in the UK Holstein population in the last decade, although it has yet to reach critical levels. Optimised selection could be used when selecting parents of future progeny test bulls to control the rate of inbreeding in the UK dairy population. Composition of the breeding goal should be considered when using optimised selection.

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Impact of nonadditive genetic effects in prediction of breeding values for dairy fertility traits

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Introduction Inbreeding depression leads to the reduction of the mean phenotypic value. There has been a steady increase in inbreeding (F) in the UK since the introduction of reproductive techniques (AI, MOET). There has been an increase in the percent Holstein (%H) in the UK population due to the influx of North American Holstein genes. Crossing these Holsteins to British Friesians can result in the favourable effect of heterosis (het), whereby crossbred progeny out-perform the mid-parent mean for that trait. Of the heterosis in the F_1 population, a proportion is lost due to recombination (rec) between parental line genes and is a measure of the epistatic interaction of genes. The purpose of this study was to examine the impact of nonadditive genetic effects (F, het, rec, %H) on the estimation of dairy cow fertility breeding values in the UK.

Materials and methods The pedigrees of animals in the most recent UK fertility index BLUP evaluations file (Wall *et al*., 2003) with 4 or more generations of complete information were extracted from the Holstein UK database. Inbreeding coefficients (F) were calculated for these 408,847 animals (Kearney *et al*., 2003). het = $P_S(1\text{-}P_D) + P_D(1\text{-}P_S)$ and rec = $P_D(1\text{-}P_D) + P_S(1\text{-}P_S)$ were calculated for all cows where P_S and P_D are the proportion of Holstein in the sire and dam respectively. F, het, rec and %H were fitted as covariates in the models (see Wall *et al*., 2003) for all traits (milk kgs at day 110, MILK; body condition score on a 1-9 scale, BCS; calving interval, CI; days in milk until first service, DFS; non-return rate after 56 days, NR56, and number of inseminations resulting in a calf, INS) and analysed using an exact solver in PEST (Groeneveld *et al*., 1990). Bivariate sire maternal-grandsire analyses of MILK paired with each of the other five traits (CS, CI, NR56, DFS and INS) were carried out to account for selection on yield in the analysis. This provided solutions for each of the covariates and their standard errors. T-tests were performed for each covariate and significant covariates added to the models. BLUP analyses were run with and without fitting these additional effects in the model and the effect on breeding value estimations was estimated by the rank correlation between the two analyses.

Results Inbreeding had a significant and negative effect on all traits. %H was significant for CI, BCS, MILK and INS, het and rec was significant for MILK and DFS. The effect of 6.25% F, relative to a non-inbred animal was; 2.3 days increase in CI, 0.17 units decrease in BCS, 0.25 kg decrease in MILK, 1.125 days increase in DFS, 0.025 increase in INS. The effect of 100% Holstein relative to 100% Friesian; 9.9 day increase in CI, 1.94 units decrease in BCS, 3.5 kg increase in MILK and 0.15 insemination increase in INS. Accounting for nonadditive genetic effects in the model, on average, causes a very slight change in the index and its components in an unfavourable direction (e.g., average value for CI increases). The rank correlations between the PTAs and the fertility index (with and without the additional nonadditive effects in the model) was over 0.99. There is little change in overall rank of animals by fitting these additional effects in the model.

Table 1: Solutions for the nonadditive genetic covariates from the bivariate analyses (s.e. in brackets).

	F	het	rec	%H
CI	36.89	-2.34	-2.34	9.90
(days)	(6.85***)	(1.26)	(1.26)	(2.39***)
BCS	-2.68	-0.10	-0.01	-1.94
(1-9)	(0.27***)	(0.12)	(0.08)	(0.23***)
MILK	-4.02	0.57	-1.45	3.46
(kg)	(0.45**)	(0.13***)	(0.11***)	(0.25***)
DFS	17.91	-1.63	-2.15	3.44
(days)	(3.22***)	(0.64*)	(0.81**)	(1.21)
NR56	-0.10	-0.01	-0.01	-0.03
(0/1)	(0.06***)	(0.01)	(0.01)	(0.02)
INS	0.45	-0.02	-0.02	0.15
(count)	(0.14***)	(0.02)	(0.03)	(0.05**)

***, **, * 0.1, 1 & 5% significance respectively.

Conclusions Nonadditive effects of inbreeding, heterosis, recombination loss and percent Holstein were shown to have a significant effect on some or all of the traits used in the estimation of the UK fertility index. However, the rank correlation between the PTAs using models with and without the significant inbreeding effects was high. On closer examination it could be seen that there was a slight re-ranking of bulls and changes in the PTAs. As the proportion of animals in higher inbreeding classes rises it will be necessary to consider the effect of inbreeding in the estimation of animals breeding values for fertility and correlated traits.

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Description of weight, fat and muscle in growing lambs using random regression

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Introduction Precise description of growth and development is important for efficient lamb production. In order to meet tight market specifications, lamb producers require accurate genetic information to make informed selection and management decisions on their animals. There is also interest in selection of animals with more efficient growth and development patterns, and information is needed on how carcase traits are correlated to each other and how they can develop over time. Hence, the aim of this study was to evaluate repeated weight, fat and muscle measures on Poll Dorset sheep using random regression (RR) models to investigate how these traits change through time.

Materials and methods Univariate RR models were fitted to three data sets comprising 32,410 weight records and 19,420 fat depth (FD) and 19,704 eye muscle depth (EMD) measurements from approximately 12,205 Poll Dorset sheep, collected between 1994 and 2002. These animals descended from around 460 sires and 6,719 dams with a total of 20,107, animals in the pedigree. Fixed effect corrections varied across the whole trajectory by nesting Legendre polynomials of age within each level of rear type (single, twin triplet) and dam age (12 classes). A quartic polynomial of age was used for the mean population curve in the weight analysis and a quadratic was used for the mean curve in the fat and muscle analyses. Contemporary groups were fitted as class variables unique across ages of measurement. A quadratic Legendre polynomial of age was used for the random components in the weight analysis with the exception of maternal genetic effects, which were fitted using a linear polynomial. Linear polynomials of age were used for the random regressions in the fat and muscle analyses, which only included direct genetic and environmental effects. Heterogeneous error variances were fitted for each of the three traits comprising ten 30-day age windows. All analyses were performed using ASReml (Gilmour *et al.*, 2002).

Results

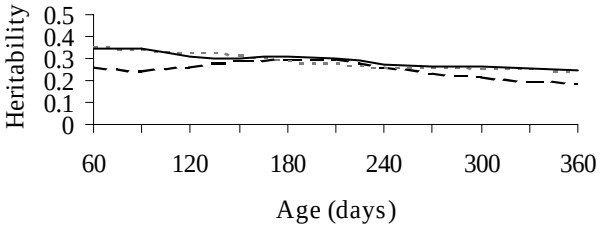

Figure 1. Heritability of weight (dashed line), fat (dotted line) and muscle depth (solid line) over time

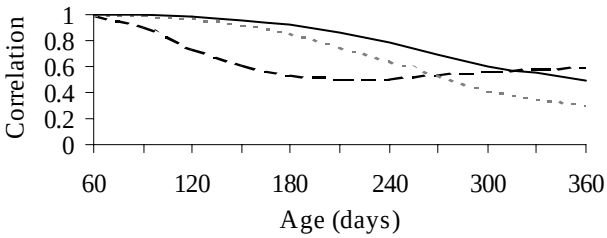

Figure 2. Genetic correlations between weight (dashed line), fat depth (dotted line) and muscle depth (solid line) measures at day 60 and other ages

Heritability was shown to remain relatively constant for weight measures throughout the 300-day trajectory ranging between 0.2 and 0.3, however, it declined unexpectedly late in the trajectory (>240 days). This coincided with an increase in permanent environmental effects as a proportion of phenotypic variance, hence there may be some partitioning problems between these two effects at older ages. Heritability for FD and EMD declined with age staring around 0.35 and declining to 0.25 at later ages and this decline corresponds to a similar pattern of variance partitioning between direct genetic and environmental effects as was seen in the weight traits at later ages. Nonetheless, estimates of heritability for the three traits were reasonably consistent with literature values at specific ages (Fogarty, 1995). Figure 2 shows how genetic correlations between weight measures at day 60 and other ages declined from unity down to 0.5 at 210 days where it plateaus for the rest of the trajectory. Furthermore, the FD and EMD correlations followed a similar pattern, albeit declining less rapidly at younger ages. Figure 2 shows the correlations between repeated measures of FD and EMD declining from unity down to 0.3 and 0.5 respectively between measures taken at 60 and 360 days. These correlations indicate that different animals have different genetic potential for growth as well as development of fat and muscle at different ages throughout life.

Conclusions This study demonstrated the relationships between measures of weight, fat and muscle in growing lambs, which is of enormous interest to the lamb industry. In addition, the analysis yielded genetic parameters in agreement with literature estimates at specific ages. Finally, for random regression models to be included in routine analysis of sheep carcase measures, an increase in the level of recording of such traits in industry would be required.

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Beef from the suckler herd: 1. Effect of origin of dam genotype on maternal characteristics and performance of progeny

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Introduction Traditionally, the dairy herd has been the primary source of cross-bred females for use as beef suckler cows in Northern Ireland. However, in view of concerns relating to potential detrimental effects of increasing Holsteinisation of the dairy herd on progeny carcass quality and herd fertility, there has been increasing interest in retaining beef-bred heifers for use as replacements in the beef herd. The objective of this study was to evaluate the effect of dam genotype, originating from either dairy or suckler herds, on maternal and progeny characteristics.

Materials and methods An extensive on-farm study involving 43 suckler herds across Northern Ireland was undertaken to examine the influence of dam breed on performance attributes of the suckler herd. Herd owners recorded data on dam genotype and calving details, including incidence and extent of dystocia. Cow fertility was assessed as 'reappearance rate' at 390 d, a measure of whether or not a cow had produced another calf within 390 d post-calving. Carcass weight, conformation and fat classifications were recorded from all progeny. Age at slaughter and carcass value (£) was subsequently calculated. Data were collated into four specific groups according to dam genotype, as follows : (1) Angus or Hereford x Friesian, (2) Continental x Friesian, (3) Angus or Hereford x Continental and (4), ¾ (or greater) Continental bred cows. Analyses were undertaken using the REML technique in Genstat 5, except for fertility data which were analysed using a binomial model with a logit link function.

Results The influence of dam breed group on dystocia and fertility parameters is presented in Table 1. Dystocia score was significantly (P<0.05 or greater) lower in dams with Angus or Hereford x Continental genotype compared to Continental x Friesian and ¾ or more Continental dam types. Dams of ¾ or more Continental breeding tended to have the poorest fertility with only 47% having reappeared by 390d, while dams of Angus or Hereford x Continental breeding tended to have best fertility (54%), although these differences were not significant (P>0.05).

Table 1 The influence of dam breed group on dystocia and fertility

Dam breed group	Dystocia[#]		% Reappearance at 390 days	
	No. Observations	Score	No. Observations	Value
Angus or Hereford x Friesian	712	149[ab]	621	49
Continental x Friesian	1482	153[b]	1273	49
Angus or Hereford x Continental	328	140[a]	183	54
¾ Continental or more	2429	151[b]	1675	47
Mean SED		4.1**		3.3 [NS]

[#] 100 = unassisted, 500 = caesarean section Means with differing superscripts are significantly different (P<0.05)

Progeny carcass data from dams of each of the four groups evaluated are presented in Table 2 (data corrected to constant slaughter age). Progeny from dams with Angus or Hereford genes had lower carcass weights, with carcasses of Angus or Hereford x Friesian dams being significantly (P<0.01) lighter than those of progeny from Continental x Friesian and ¾ or more Continental cows. Dam breed accounted for differences in carcass fat and conformation scores of some 0.14 and 0.13 units respectively. Progeny of Angus or Hereford x Friesian dams had significantly higher carcass fat scores than progeny of the other dam groups (P<0.05 or greater), while progeny of ¾ or more Continental dams had significantly lower fat scores than either dam group containing Friesian genes (P<0.01 or greater). Progeny carcass conformation improved as the influence of dairy genes in the dam was removed, with progeny of Angus or Hereford x Continental, and ¾ or more Continental genotype dams having significantly higher conformation scores than those of progeny from the other two dam groups (P<0.05 or greater). This resulted in some 74% of carcasses from the former groups achieving the premium E, U or R grades, compared with 67% and 69% of progeny from Angus or Hereford x Friesian and Continental x Friesian dams respectively. Progeny carcass value differed by up to £15 between dam breed groups, being significantly (P<0.05 or greater) lower for carcasses from Angus or Hereford x Friesian dams compared with progeny from the other dam groups, which were similar (P>0.05).

Table 2 The influence of dam breed group on progeny characteristics

Dam breed group	No. Obs.	Carcass weight (kg)	Carcass fat class[1]	Carcass conformation [2]	Percentage EUR grades	Carcass value (£) [3]
Angus or Hereford x Friesian	653	313[a]	3.03[c]	3.16[a]	67[a]	518[a]
Continental x Friesian	1259	319[b]	2.95[b]	3.20[a]	69[ab]	531[b]
Angus or Hereford x Continental	288	315[ab]	2.91[ab]	3.28[b]	74[b]	528[b]
¾ Continental or more	1649	319[b]	2.89[a]	3.29[b]	74[b]	533[b]
Mean SED		2.0	0.032	0.032	2.3	3.9
Significance		**	***	***	**	***

[1] 5 point scale; 1 = leanest, 5 = fattest [2] EUROP = 5, 4, 3, 2, 1 respectively [3] based on price grade structure in Northern Ireland
Means with differing superscripts are significantly different (P<0.05)

Conclusions The data indicate that carcass conformation was better with Angus or Hereford x Continental or ¾ or more Continental dams compared to dams containing Friesian genes. The use of early maturing beef x Friesian dams resulted in progeny with lighter, fatter carcasses and lower carcass values.

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Comparison of manual and automatic segmentation of muscle regions in spiral computed tomography images of sheep

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Introduction Computed tomography (CT) gives accurate *in vivo* estimates of sheep carcass composition based on information provided by cross-sectional CT reference scans (Young *et al.*, 2001). Spiral CT is a novel imaging technology in which contiguous cross-sectional scans of a known thickness are collected. This data allows the reconstruction of images in three dimensions, giving the possibility of a comprehensive assessment of characteristics that are defined in terms of shape, such as conformation and muscularity. The development of automatic procedures for image analysis is of high priority due to the large amount of information contained in the spiral scans. The first step in image analysis is isolating the carcass components of each cross-sectional image, called segmentation. An algorithm to automatically segment the cross-sectional images in the spiral scan was developed, with the objective of investigating *in vivo* assessments of conformation and muscularity in sheep. The aim of this study was to compare the muscle areas obtained by manual and automatic segmentations.

Materials and methods Image analysis was performed on spiral CT scans taken from 10 Scottish Blackface male lambs. Each spiral cross-sectional image, beginning at the first image in which the ischium appeared up to the image showing the last lumbar vertebra (pelvic region), was manually segmented (MS) by three experienced operators and automatically segmented (AS) using a new mathematical algorithm (Glasbey and Young, 2002). Preliminary subjective assessment of AS spiral images suggested that this region of the leg was the most complex for the automated procedure. Twenty-five cross-sectional images were included in this specific region, on average. After segmentation, muscle areas in each image were calculated using the STAR software (Mann *et al.*, 2003). Simple correlations between the measurements obtained after MS and AS were calculated. The relationship between MS and AS was also studied by linear regression analysis. The distribution of residuals was investigated across the cross-sectional images (Genstat v.4.1; Lane and Payne, 1996).

Results The AS would not run on the spiral scans of one lamb as the software was unable to identify the appropriate skeletal landmarks. The correlation of muscle area between MS and AS in the remaining scans was approximately 0.98. The regression analysis between MS and AS showed high R^2 values for all operators (Figure 1). However, a larger dispersion was observed for muscle areas below 10 cm^2. The residuals of the regression analysis were plotted against cross-sectional image in the spiral scan (Figure 2). The complexity of the pelvic region for AS was confirmed by the larger difference between MS and AS that was observed from the hip joint forward (cross-sectional image 25).

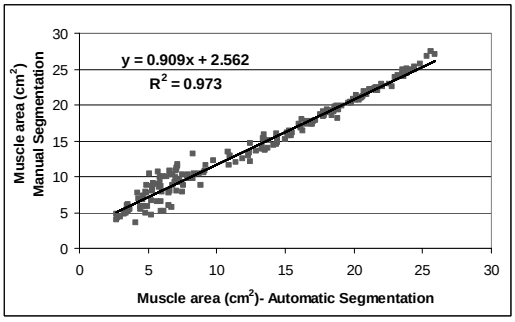

Figure 1 Regression of muscle area from MS on the muscle area after AS

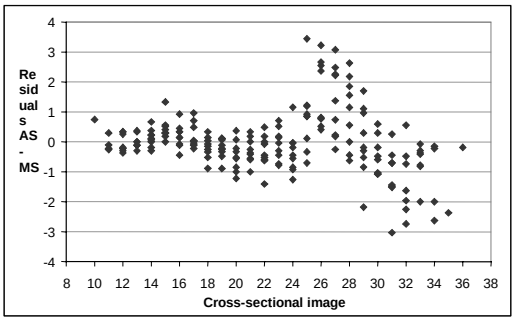

Figure 2 Distribution of regression residuals along the cross-sectional images in the spiral CT scans

Conclusion This study shows a high association between the muscles areas calculated after MS and AS. Nevertheless the quantitative data and qualitative evaluation of the AS images indicated that the performance of the AS needs to be improved in the region from the hip joint to the last lumbar vertebra. The incorporation of semiautomatic procedures may improve the quality of the segmentation in this area.

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Beef from the suckler herd: 2. Evaluation of the performance of some of the commonest dam genotypes present in the Northern Ireland suckler herd

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Introduction Fifty-three per cent of prime beef production in Northern Ireland is currently sourced from the beef herd and this proportion is likely to decrease post implementation of the Mid-Term Review (MTR) of the Common Agricultural Policy (CAP). The Northern Ireland suckler industry currently incorporates a very diverse range of genotypes which produces a very varied product in terms of carcass weight, fatness and conformation. However, there is an increasing need for the industry to produce a more consistent product, as beef production will be market driven in a subsidy free environment post implementation of the MTR of the CAP. The objective of the present study was to evaluate the potential of 10 of the most common dam genotypes used for beef production in Northern Ireland.

Materials and methods An extensive on-farm study involving 43 suckler herds across Northern Ireland was undertaken to evaluate the potential of differing dam genotypes for beef production. Herd owners recorded data on dam genotype and calving difficulty. Cow fertility was assessed as 'reappearance rate' at 390 d, a measure of whether or not a cow had produced another calf within 390 d post-calving. Carcass weight, conformation and fat classifications were recorded from all progeny. Age at slaughter and carcass value (£) was subsequently determined. Analyses of maternal and progeny characteristics were undertaken using the REML technique in Genstat 5, except for fertility data which was analysed using a binomial model with a logit link function.

Results The influence of dam genotype on dystocia, fertility and carcass parameters is presented in Table 1 (carcass data corrected to constant slaughter age). Angus and Limousin cows tended to have lower dystocia scores than the other genotypes evaluated, being significantly (P<0.05 or greater) lower than Angus x Friesian, Simmental x Friesian and Simmental dams. Simmental dams had higher (P<0.05) dystocia scores than Limousin x Friesian dams. Differences recorded between other breeds did not reach statistical significance (P>0.05). Dam genotype had no significant (P>0.05) effect on reappearance rate. Progeny of Limousin x Simmental dams had significantly (P<0.05 or greater) lighter carcasses than all other breeds with the exception of progeny of Angus x Friesian dams. Progeny of Angus x Friesian dams tended to have lighter carcasses than progeny of other breeds, being significantly lighter than those of Limousin x Friesian, Charolais, Limousin and Simmental x Charolais dams (P<0.05 or greater). Carcass conformation was poorest in progeny from Simmental x Friesian dams, significantly lower than progeny from all dams with the exception of those from Angus and Hereford x Friesian dams (P<0.05 or greater). However, progeny of Angus, Hereford x Friesian and Simmental were also poorly conformed. Simmental x Charolais dams produced more highly conformed carcasses than most other breeds (P<0.05 or greater) with the exception of those of Limousin and Charolais dams which were also well conformed. Carcass fat classification showed a small range across dam breed types, though progeny of Limousin dams had lower fat class scores than progeny of all breeds with the exception of Limousin x Simmental and Charolais dams (P<0.01 or greater). In contrast, progeny of Angus x Friesian dams tended to have higher fat class scores than several other breeds. Progeny carcass value differed by up to £33 between dam genotypes, being significantly (P<0.05 or greater) lower with progeny of Limousin x Simmental dams than most other breeds (except for progeny of Angus x Friesian, Simmental x Friesian and Hereford x Friesian dams). In contrast, progeny of Simmental x Charolais and Limousin dams realised highest carcass values, significantly (P<0.05 or greater) higher than other breeds with the exception of progeny of Limousin x Friesian and Charolais dams.

Table 1 The influence of dam genotype on dystocia, fertility and progeny characteristics

Dam genotype	Dystocia		Reappearance 390 d		No.	Carcass	Carcass	Carcass	Carcass
	No. Obs	Score[1]	No. Obs	%	Obs	weight (kg)	fat class[2]	conformation[3]	value (£)[4]
Angus	149		345	45	305	320^{bcd}	3.08^{de}	3.16^{abc}	533^{bcd}
Angus x Friesian	162		487	52	488	315^{ab}	3.13^{e}	3.25^{bcd}	525^{ab}
Charolais	159		270	48	267	322^{cd}	2.95^{abc}	3.35^{de}	542^{def}
Hereford x Friesian	156		134	54	166	319^{bcd}	3.05^{cde}	3.19^{abc}	532^{abcd}
Limousin	152		428	46	411	325^{d}	2.89^{a}	3.37^{de}	547^{ef}
Limousin x Friesian	159		595	53	575	322^{cd}	3.03^{cd}	3.31^{d}	540^{def}
Limousin x Simmental	165		110	55	110	309^{a}	2.91^{ab}	3.28^{cd}	518^{a}
Simmental	168		503	50	470	320^{bc}	3.02^{bcd}	3.24^{bc}	537^{cd}
Simmental x Charolais	162		98	55	140	326^{d}	3.06^{cde}	3.41^{e}	551^{f}
Simmental x Friesian	164		431	49	437	318^{bc}	3.04^{cde}	3.15^{a}	531^{abc}
Mean SED		6.1		4.8		3.2	0.050	0.048	6.0
Significance		***		NS		***	***	***	***

[1] 100 = unassisted, 500 = caesarean section; [2] 5 point scale: 1 = leanest, 5 = fattest; [3] EUROP = 5, 4, 3, 2, 1 respectively; [4] based on price grade structure in Northern Ireland; Means with differing superscripts are significantly different (P<0.05)

Conclusions Progeny carcass weights and values differed by 17 kg and £33 respectively between dam genotypes, with progeny of predominantly continental dams tending to realise highest values for these parameters. However, reappearance rate at 390 days was low for all breeds, indicating a major fertility problem in the suckler herd.

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Estimation of muscle volume by automated image analysis of spiral computed tomography scans in sheep

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Introduction Computed Tomography (CT) is a non-invasive method used to provide accurate information on body composition of breeding animals. It is being applied in sheep breeding programmes in the UK to predict whole carcass composition in terms of muscle, fat, and bone. Previous studies established the equations to predict the total weights of muscle, fat and bone in different breeds from conventional CT scans. The average prediction accuracies were 92, 96 and 81% for muscle, fat and bone, respectively, in meat sheep and hill breed lambs (Young *et al.*, 2001). Spiral CT scans provide a means of assessing directly the composition of the whole body and its different regions, in addition to muscularity and conformation. Although an automatic procedure to quantify the carcass components in cross-sectional images was developed previously, new software to segment images from spiral CT scans is now being evaluated. The aim of this study was to determine the accuracy of the automated image analysis in the estimation of total muscle volume of the hind leg, which is the most valuable joint.

Methods Fourteen Texel and Scottish Blackface male lambs were CT scanned before slaughter. Spiral CT scans were taken of each animal. Each spiral scan sequence contained contiguous cross-sectional images which were 8mm thick. For this study, only the cross-sectional images from the proximal third of the tibia to the last lumbar vertebra (hind leg) were analysed. Each image was automatically segmented to electronically remove all parts of the image which were not part of the carcass joint, using an algorithm based on the method described by Glasbey and Young (2002). After segmentation, the muscle area for each image was estimated using STAR software (Mann *et al.*, 2003). To calculate the total volume of muscle in the leg, the muscle areas of each segmented image were added together and then multiplied by the thickness of the cross-sectional image (8mm). Lambs were slaughtered using standard procedures and weights of muscles were obtained by physical dissection of the left leg. Data were analysed by simple linear regression (Genstat v.4.1; Lane and Payne, 1996). Muscle weights (kg left leg x 2) and CT muscle volume were the dependent and independent variates, respectively.

Results The automatic segmentation failed to run through the spirals of 4 of the 14 lambs because the algorithm could not identify the skeletal landmarks. Figure 1 illustrates the strong association (R^2 = 98%) between the muscle volume calculated from the spiral CT scan and the corresponding muscle mass obtained by dissection. Because the intercept was not significant, only the regression coefficient was fitted, which represents the density of the muscle (mass/volume). The estimated value of this parameter was 0.990 ± 0.006 g/cm^3. The density of the skeletal muscle can be defined as the function of fat and lean density (0.92 and 1.04 g/cm^3, respectively; Nord and Payne, 1995). With 2% intramuscular fat (data not presented) muscle density would be approximately 1.02 g/cm^3, which is similar to the estimated regression coefficient.

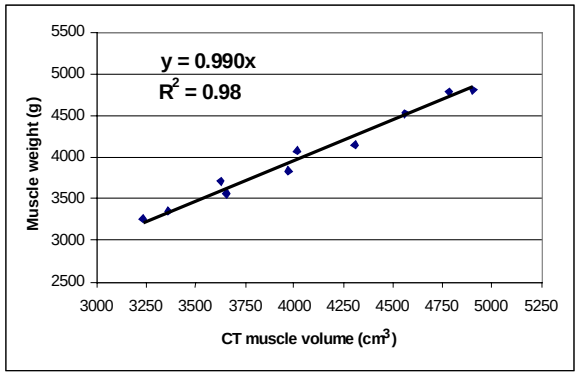

Figure 1 Association between muscle weight of the leg and muscle volume calculated from *in vivo* spiral CT.

Conclusion Although these results are only preliminary because of the small number of animals, the high R^2 value suggest that it is possible to calculate with high accuracy the muscle mass in the hind leg using spiral CT scans. Implementation of automated image analysis procedures is restricted by the failure of the program to analyse some of the images, but not by the accuracy obtained.

Acknowledgements We are grateful to Defra for supporting this work.

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Beef from the suckler herd: 3. Effect of terminal sire breed on subsequent suckler cow performance and progeny characteristics

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Introduction Breed of terminal sire used in suckler beef systems is one of the most important decisions taken by beef producers, as the terminal sire contributes 50% of the total genetic make-up of the progeny. In view of the inherent variability of carcass weight and grading characteristics of progeny, the objective of the present study was to evaluate the potential of a range of terminal sire breeds for beef production under Northern Ireland conditions.

Materials and methods An extensive on-farm study involving 43 suckler herds across Northern Ireland was undertaken to examine the influence of breed of terminal sire on maternal and progeny factors. Data on sire breed were recorded at each calving, along with an assessment of the extent of dystocia. Fertility of the suckler cow, as influenced by breed of terminal sire, was evaluated by determining the 'reappearance rate' at 390 d of dams calving to each sire breed. Carcass weight, conformation and fat class was recorded from all progeny. Age at slaughter and carcass value (£), not including breed bonuses, was subsequently calculated. Data were analysed using the REML technique in Genstat 5, with the exception of fertility data which were analysed using a binomial model with a logit link function.

Results The influence of sire breed on dystocia and fertility parameters is presented in Table 1. Dams calving to Belgian Blue sires had significantly (P<0.01 or greater) higher dystocia scores than those calving to the other sire breeds with the exception of Salers and Simmental-sired progeny, while cows calving to Angus sires had the lowest scores. Cows calving to Angus sires ranked best for reappearance rate, significantly (P<0.05) better than dams calving to Belgian Blue and Limousin sires which ranked lowest. In addition, cows calving to either Belgian Blue or Limousin sires had poorer reappearance rates than dams calving to Charolais sires, and to Blonde d'Aquitaine sires (Belgian Blue only) (P<0.05).

Table 1 The influence of sire breed on dystocia and fertility of the suckler cow

Sire breed	Dystocia[#]		% Reappearance at 390 days	
	No. Observations	Score	No. Observations	Value
Angus	563	146[a]	498	53
Blonde d'Aquitaine	360	149[ab]	163	52
Limousin	1390	150[ab]	989	44
Charolais	2154	154[ab]	1893	50
Simmental	392	158[abc]	206	47
Salers	299	164[bc]	293	50
Belgian Blue	326	169[c]	229	40
Mean SED		6.6***		4.7*

[#] 100 = unassisted, 500 = caesarean section Means with differing superscripts are significantly different (P<0.05)

The influence of sire breed on progeny characteristics is presented in Table 2 (data corrected to constant slaughter age). Progeny of Angus and Salers sires had lighter carcass weights than progeny of all other sire breeds, being significantly lower than progeny of Limousin and Simmental sires, which were lower than progeny of Charolais and Blonde d'Aquitaine sires, whilst Belgian Blue sired progeny produced the heaviest carcasses (P<0.05 or greater). The progeny of Angus and Salers sires had the poorest fat and conformation classifications, having significantly higher fat and lower conformation scores than progeny of all other sire breeds (P<0.05 or greater). In contrast, progeny of Blonde d'Aquitaine and Belgian Blue sires had lowest carcass fat scores (P<0.05 or greater), while progeny of Belgian Blue sires had highest conformation (P<0.001). However, Limousin-, Blonde d'Aquitaine- and Charolais-sired progeny were also well conformed. Progeny of Belgian Blue sires realised highest carcass values, being significantly higher than progeny of Charolais and Blonde d'Aquitaine sires, which were higher than progeny of Limousin and Simmental sires, whilst progeny of Angus and Salers sires realised lowest carcass values (P<0.01 or greater).

Table 2 The influence of sire breed on progeny characteristics

Sire breed	No. Obs.	Carcass weight (kg)	Carcass fat class [1]	Carcass conformation [2]	Percentage EUR grades	Carcass value (£) [3]
Angus	411	306[a]	3.34[e]	3.12[b]	63[b]	505[a]
Belgian Blue	190	334[d]	2.84[b]	3.58[e]	83[d]	566[d]
Charolais	2008	324[c]	2.94[c]	3.29[cd]	70[c]	544[c]
Blonde d'Aquitaine	335	327[c]	2.73[a]	3.30[cd]	68[bc]	550[c]
Limousin	953	318[b]	2.98[c]	3.34[d]	71[c]	535[b]
Salers	170	307[a]	3.16[d]	2.98[a]	55[a]	504[a]
Simmental	230	318[b]	2.99[c]	3.24[c]	65[b]	531[b]
Mean SED		3.0***	0.048***	0.047***	3.3***	5.7***

[1] 5 point scale; 1 = leanest, 5 = fattest [2] EUROP = 5, 4, 3, 2, 1 respectively [3] based on price grade structure in Northern Ireland
Means with differing superscripts are significantly different (P<0.05)

Conclusions The data indicate that whilst traditional Angus sires are favourable for dystocia and fertility, they produce progeny with lighter, fatter, lower value carcasses relative to those of the main Continental sire breeds. Use of Belgian Blue sires increased dystocia, whilst producing higher value carcasses. Charolais and Blonde d'Aquitaine sires also produced higher value carcasses without increasing dystocia. Overall, fertility was low across all breeds.

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Selective breeding and farm animal welfare – risks, opportunities and controls

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Breeding for productivity In the past, concerns about farm animal welfare have mainly related to husbandry systems, with much less attention given to the effects of breeding. Over the years selective breeding programmes have led to great increases in productive output and efficiency in farm livestock, particularly poultry, pigs and dairy cattle. These species have also become increasingly specialised for a specific function such as producing eggs, meat or milk. But there is strong evidence that in many cases where there is a narrow focus on improving production, these selective breeding programmes are associated with serious welfare costs (Rauw *et al*., 1998), despite the existence of legislation that, in theory, prohibits such a situation. The European Directive on farm animal welfare (Directive 98/58/EC) states that:'*No animals shall be kept for farming purposes unless it can reasonably be expected, on the basis of their genotype or phenotype, that they can be kept without detrimental effect on their health or welfare.'* Negative effects of selective breeding on welfare are due to over-emphasis on production traits in relation to other aspects of the animal's biology. The animal is 'genetically pre-programmed' to allocate a disproportionately large amount of resources to the particular production trait (such as producing a large breast muscle or huge quantities of milk), often at the expense of the rest of the body's functions. The biological balance of the animal is disturbed, with much of the body's emphasis on particular traits. In their report on the welfare of chickens (2000), the European Commission's Scientific Committee on animal health and animal welfare concluded that: '*…the major welfare problems in broilers are those which can be regarded as side effects of the intense selection mainly for growth and feed conversion.*' Animals selected on the basis of production often maintain high output whatever the cost to them. For example, high yielding dairy cows may continue to produce milk even when in negative energy balance. Body reserves will be mobilised to allow milk production to continue which, if prolonged, can lead to health and fertility problems (Pryce *et al*., 2002).

Breeding for welfare Poorer welfare need not be an inevitable consequence of selective breeding. Used responsibly, breeding can lead to improvements in welfare if based on a broader set of objectives which give health and welfare adequate weight. Whilst the Sustainable European Farm Animal Breeding and Reproduction project (SEFABAR, 2003) has identified a continued resistance on the part of some in the breeding industry to accept responsibility for animal welfare problems, it is encouraging that an approach that includes welfare parameters in breeding programmes has been endorsed, and is starting to be applied, by several European breeding companies. However, selection for improved welfare itself raises some important questions. For instance, selecting for greater resistance to a specific disease may bring immense benefits, but care must be taken to ensure that highly focused selection of one genotype does not remove from the gene pool individuals or strains possessing resistance to other important diseases. In addition, selection for animals who show less overt distress when kept in poor husbandry systems raises some extremely important ethical questions and dilemmas relating to issues such as the 'integrity' of an animal, breed or species, and the acceptability of an approach that aims to produce animals that fit into systems, rather than *vice versa.*

Decision-making and control Despite the enormous effects that selective breeding can have on farm animal welfare, it is essentially unregulated. The farm animal breeding industry is comprised of huge, multi-national companies. In some cases, companies are reluctant to release information on selection indices, making independent assessment very hard. Whilst breeding for improved welfare can be economically beneficial where individuals have high economic value (like the dairy cow), in other cases such as meat chicken breeding where an individual animal's value is very low, major conflicts – real or perceived - may remain between commercial priorities and animal welfare. For this reason, and because the effects of selective breeding on welfare can be so great, the RSPCA believes a framework must be established for mandatory independent appraisal and statutory control of breeding programmes, in relation to animal welfare. Such an approach is also needed to consider the ethical questions posed by extreme examples of selective breeding, where the fundamental nature or behaviour of the animals involved may be altered in the pursuit of specific goals. Consumers could also have a very powerful role to play in influencing breeding programmes by actively seeking – and so providing a market for - products from animals who have experienced fewer or no genetically-related welfare problems, though the public's poor understanding of animal breeding issues must first be overcome.

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Relationship between fineness of grind of cereals and particle size in, and viscosity of, liquid diets for pigs.

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Introduction Liquid feed has to be pumped through pipes to deliver it to pigs. The dry matter content of the diet and the distribution of particle size affects a number of physico-chemical properties of the process. These determine the initial power needed to start a pump from the stationary position and to circulate the feed through the system. Particle size also affects the homogeneity of the diet and the extent to which separation occurs during pumping and after delivery to the trough. In *ad lib.* feeding systems there is an opportunity for feed particles to hydrate and increase in size. These changes could have a significant effect on viscosity and hence the DM concentration of the diet that could be pumped at a particular power loading. In dry diets, particle size distribution is normally assessed and described on the basis of simple dry sieving. However, this method cannot be used with liquid diets. In other applications, the sizes of particles in a suspension have been assessed using laser particle size analysis (Chmelik *et al.* 2001). This study was designed to 1) Determine the extent to which particle size distribution was changed by different disk mill settings; 2) Examine the change in particle size distribution resulting from steeping the cereal component in water for 24h; 3) Determine the effect of particle size on viscosity.

Material and methods Samples (*ca.* 2kg) of barley (*var.* Static; 82.7% DM) and wheat (*var.* Claire; 86.7% DM) were ground though a Skiold SK2500 disk mill (Danagri-3S, Bridgnorth, UK) at settings of 0, 0.75 and 1.0. Samples (60g) of both cereals at all grind settings were mixed with 150 mL of water (1:2.5; w:v) and steeped for 24h. Particle size analysis was performed, in triplicate, on a Laser Particle Size Analyser (Mastersizer X. Malvern Instruments Ltd., Malvern, UK). The percentage of particles falling into five particle size ranges (Table 1) was calculated. Statistical analyses of mean percentage of particles in each size range due to disk mill setting and hydration was conducted using analysis of variance. The viscosity of each sample was determined using a Rheometer (Brookfield Model DV III, Stoughton, MA, USA). Samples were analysed ten times with a 10-second interval between each reading.

Results Particle size was not normally distributed but very skewed towards the larger particle size (Table 1). The disk mill grind setting had no significant effect (P >0.05) on particle size distribution. Irrespective of grind setting, the majority of particles (64-88%) were greater than 500μm and 82-94% were greater than 250μm. Steeping resulted in statistically significant differences (P <0.05) in particle size distribution. In Barley these differences were inconsistent. However, in wheat steeping resulted in significant increases (P < 0.05) in the percentage of particles <125 μm with a significant reduction in the percentage of larger particle sizes. Viscosity of barley samples remained constant (<200 mPasc). The viscosity of liquid wheat was reduced from 692 mPasc (2h) to 79 mPasc (24h).

Table 1. Particle size (μm) distribution (%) of barley or wheat, ground at disk mill settings of 0, 0.75 or 1, and steeped for 0 or 24 h

	Barley						Wheat					
Disk mill setting	0		0.75		1		0		0.75		1	
Steep Time	0 h	24 h	0 h	24 h	0 h	24 h	0 h	24 h	0 h	24 h	0 h	24 h
<125 μm	9.3[a]	15.8[a]	8.1[a]	22.3[a]	3.3	5.8	6.5[a]	29.3[a]	8.4[a]	26.4[a]	4.9[a]	29.3[a]
125-250 μm	5.7	3.9	3.2	5.8	2.3	4.7	15.2[a]	5.1[a]	7.9[a]	4.8[a]	7.5[a]	4.7[a]
250-500 μm	15.5[a]	11.4[a]	8.9	7.4	6.4	8.3	16.4[a]	8.7[a]	11.9[a]	6.0[a]	13.2[a]	4.8[a]
500-1000 μm	42.5[a]	36.5[a]	25.4[a]	3838[a]	24.3[a]	32.6[a]	48.0[a]	27.9[a]	29.1[a]	20.1[a]	41.2[a]	18.8[a]
1000-2000 μm	27.0[a]	32.4[a]	54.0[a]	39.3[a]	65.2[a]	52.2[a]	23.6[a]	28.6[a]	43.0	42.9	33.6[a]	42.6[a]

[a] differences between 0 and 24h means, in each particle size range, for the same grain/grind size are significantly different (P <0.05)
s.e.m Barley = 0.49 s.e.m. wheat = 0.23

Conclusions Hydration resulted in an apparent increase in the number of small particles <125μm and reduced the apparent proportion of large particles. This suggests that a proportion of small and medium sized particles are loosely aggregated to form large particles, which disaggregate during steeping. The results obtained in this study suggest that steeping had little effect on the viscosity of liquid barley but that steeping could activate natural enzymes, which reduce the viscosity of wheat based diets.

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Physico-chemical aspects of liquid feed: the effect on component digestibility in growing/finishing pigs of 1) dietary dry matter concentration and 2) dietary fineness of grind

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Introduction There is potential for improving the growth performance of pigs through a better understanding of factors that influence the digestibility of nutrients and energy in liquid feeds, and developing standard operational procedures for liquid feeding forms an important part of the MLC-coordinated Finishing Pigs Systems Research programme. The objective is to determine how changing the dry matter concentration of liquid feeds, or the particle size of dry ingredients used in liquid feeds, affects digestibility and retention of nutrients and energy in growing/finishing pigs.

Materials and methods Two separate metabolism studies were conducted, each using ten male modern commercial white hybrid pigs. For the duration of each trial, animals were housed individually in pens and transferred into metabolism crates for each collection period. Experimental diets were supplemented with titanium dioxide (TiO_2) at 1g/kg, and sanitised using Sanitech^{TM} (12ml per litre, activated with 2g citric acid per 12ml Sanitech) to prevent fermentation. In metabolism trial 1, a single dry meal diet was used to make five experimental diets differing only in the ratio of water: dry matter (Table 1). In metabolism trial 2, a single diet was used to prepare 10 experimental meal diets, at a single water to air-dry feed ratio of 700:300, which were differentiated by a) the hammer mill screen size used to grind the raw materials (5, 4, 3, 2 and 2*2mm), and b) whether the cereals only (COM) or whole diets (WDM) were milled. Particle size distribution of trial 2 diets was assessed by dry sieving and fineness modulus calculated for each. In both studies experimental diets were fed to one pig in each of 4 collection periods, conducted at mean pig live weights of 35, 55, 75 and 95kg. Water was available at all times from Arato 80 drinkers, each fitted with a Kent PSM-L water meter. Each collection period consisted of five days (minimum) acclimatisation followed by five days during which individual feed and water intake/waste was measured and a total collection of faeces and urine conducted, with collected material being stored at –20°C. Feed and faeces were analysed for TiO_2 and chemical components, and digestibility coefficients calculated for nutrients and energy.

Table 1 Metabolism Trial 1 Experimental diets, g/kg

Diet description					
Form of feed fed	Liquid				Dry
g air dry feed/kg feed fed	200	250	300	400	1000
ml water/kg feed fed	800	750	700	600	0
water:feed ratio of feed fed	4:1	3:1	2.3:1	1.5:1	0
water:DM[a] ratio of feed fed	4.6:1	3.5:1	2.7:1	1.7:1	0.1:1

[a] *oven dry matter content of air dry feed was 869g/kg*

Results Data from metabolism trial 1 were analysed as a 2 (rate of feeding) * 5 (ratio of water to dry meal, with linear and non-linear contrasts assessed) factorial model. Liquid feed intake (kg/pig/day) decreased as dietary dry matter (DM) concentration increased, at respective averages of 11.37, 9.47, 7.96, 5.99 and 2.13 for diets A-E (*s.e.d.=0.787, P<0.001*), although the corresponding dry matter intake was unchanged at 1.97, 2.06, 2.08, 2.09 and 1.85 (*s.e.d.=0.334, NS)*. Drinking water intake increased from 0 to 4.19 litres/pig/day with increasing dietary DM concentration, whilst total water intake, including that consumed in the feed, decreased from 8.77 to 4.11 litres/pig/day. Differences in water retention coefficients (*mean = 0.317, s.e.d.=0.0462, P=0.001*) meant that there were no significant differences in absolute retention of water (*NS*). Faecal fresh matter (FM) output (mean = 1.39kgFM/pig/day, *s.e.d.=3.2, NS*) and faecal moisture content (mean = 306gDM/kg FM, *s.e.d.=12.1, NS*) did not differ significantly between diets. Results also showed that there were no significant differences in component digestibility, or GE and N retention, between diets. Metabolism Trial 2 data were analysed as a 2 (COM or WDM) * 5 (mill screen size) factorial model. Component digestibility results are summarised in Table 2 Digestibility of dry matter (DM), gross energy (GE), crude protein (CP) and oil A differed significantly between the different mill screen sizes used to prepare the experimental diets, but not always in a systematic manner.

Table 2. Digestibility of components in metabolism trial 2 experimental diets

Screen	Dry Matter		Gross Energy		Crude Protein		Oil A	
mm	*COM*	*WDM*	*COM*	*WDM*	*COM*	*WDM*	*COM*	*WDM*
5	0.825[a]	0.796[a]	0.812[a]	0.791[a]	0.853[a]	0.836	0.753	0.656[a]
4	0.815[abc]	0.808[ab]	0.802[b]	0.793[a]	0.826[b]	0.824	0.720	0.725[b]
3	0.804[c]	0.815[bc]	0.790[d]	0.803[ab]	0.818[b]	0.844	0.743	0.767[bc]
2	0.811[bc]	0.823[bc]	0.775[cd]	0.810[b]	0.838[ab]	0.851	0.782	0.794[c]
2*2	0.821[ab]	0.826[c]	0.808[ab]	0.817[b]	0.856[a]	0.859	0.785	0.802[c]
Mean	0.815	0.813	0.801	0.803	0.838	0.843	0.757	0.749
s.e.d.	0.0061	0.0075	0.0063	0.0072	0.0130	0.0114	0.0263	0.0277
P	0.003	0.008	0.016	0.014	0.038	0.068	0.125	<0.001

Conclusions In summary, results of the current studies show that the nutritional and environmental effects of varying the dry matter concentration of pig feed over the range of 174 to 869g DM/kg feed are negligible. Additionally, it is suggested that improved component digestibility in liquid diets may be achieved by increasing the fineness of grind, particularly of the whole diet, although any such benefits are relatively small in practical terms and may be outweighed by increased feed preparation costs.

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The growth performance, carcase and meat quality of pigs finished under different housing and feeding systems: 1. liquid versus dry feeding in fully slatted and straw-bedded housing

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Introduction The MLC-coordinated Finishing Pigs Systems Research (FPSR) programme addresses industry and Government policy requirements through a multidisciplinary approach that investigates several priorities including the potential for improving production efficiency of pigs through liquid feeding. Research activity is centred at the Meat and Livestock Commission's Stotfold Pig Development Unit and uses the purpose built Finishing Systems Research Unit. Two housing systems, fully slatted *versus* straw-based, will be evaluated over four production trials designed to investigate different aspects of liquid feeding technology. This paper is based on the results of the first production trial, which compared dry and liquid feeding in a fully slatted or straw-based housing system. The objective of the current study was to determine the effect of offering the same diet in the form of either dry pellets or liquid feed, on the growth performance, carcase quality and meat eating quality of pigs growing/finishing pigs.

Materials and methods 1056 Landrace x Large White pigs were used to evaluate dry and liquid feeding in two contrasting systems of housing (straw-based v fully slatted), growing from an average of 34kg to slaughter at 104kg live weight. Each house consisted of four rooms, with four pens within each room and intakes of 32 pigs per pen. The dry and liquid feeding treatments were replicated within housing system and between rooms according to Figure 1. The dry and liquid diets used in the current study were formulated to the same nutrient specification using similar ingredients. Two diets were used for both dry and liquid fed pigs, a grower diet fed from entry to about 60 kg (14.7 MJ DE/kg, 1.2% total lysine) and a finisher diet fed from 60 kg to slaughter (14.2 MJ DE/kg, 0.9% total lysine). Dry diets were manufactured commercially in 3mm pellets and offered in *ad libitum* hoppers. Liquid diets were produced on site by milling cereals and mixing individual ingredients using the liquid feeding system, and liquid feeding was computer-controlled by feed demand at the troughs using sensors which signalled for refill on empty. Liquid feed was available *ad libitum* except for the period between 24:00 and 01:00 when the system was automatically paused, allowing pigs to clear troughs of any accumulated residues. Measurements and records that were taken using standard procedures to establish the potential effects of feeding (dry *v* liquid) and housing (straw-based v fully slatted) on pig performance, pig carcase quality and meat quality include: live weight, feed intake, nutrient analysis of feed ingredients and complete diets, mortality and other losses, slaughter weight, commercial carcase classification measurements of weight and P2, fat firmness, subcutaneous fat skatole and indole contents, and fatty acid profile, drip loss, muscle colour, simulated retail display, oxidative rancidity (TBARS) and sensory evaluation of cooked loins. Data were subjected to analysis of variance using a general linear model with model inputs of housing system, feeding system and a feeding and housing interaction term.

Figure 1 Allocation of feeding treatments (liquid v dry) according to housing system & room, 4 pens per room

Room:	1	2	3	4
Straw-based house	Liquid	Dry	Liquid	Dry

Room:	1	2	3	4
Fully slatted house	Dry	Liquid	Dry	Liquid

Results Main data are shown in Table 1. Daily live weight gain was significantly higher, whilst feed intake (on a meal equivalent basis) was significantly lower in liquid-fed pigs. The combined effect of this was a significant improvement in feed conversion ratio for liquid-fed pigs compared with pigs fed the same diet in dry pellet form. Backfat thickness (P2) was similar in liquid and dry fed pigs at an average dead weight of 77kg, and there were no significant differences in the variability of gain and carcase quality (P2) between liquid and dry fed pigs. Additionally, there were no differences of commercial importance in the fresh and sensory meat quality of liquid and dry fed pigs. Furthermore, there were no notable effects of housing on growth performance and carcase quality.

Table 1 Growth performance and carcase quality of pigs fed the same diet offered in the form of either liquid or dry pellets

	Liquid	Dry	s.e.d.	P
Feed intake (kg/pig day)				
Grower	1.44	1.47	0.040	ns
Finisher	2.22	2.39	0.053	**
Overall	1.75	1.85	0.021	***
Growth (g/day)				
Grower	717	656	17.2	***
Finisher	853	831	16.0	ns
Overall	796	754	9.6	***
Feed conversion ratio				
Grower	2.00	2.24	0.062	***
Finisher	2.60	2.89	0.075	***
Overall	2.27	2.53	0.027	***
Carcase quality				
Slaughter weight (kg)	103.6	103.7	0.54	ns
Carcase weight (kg)	76.60	77.38	0.415	0.07
Backfat P2 (mm)	11.45	11.39	0.304	ns

Conclusions Results of this production trial show that the physical performance of growing/finishing pigs was superior in liquid-fed pigs compared with pigs offered the same diet in dry pellet form. Inconsistent effects of housing on performance found in the current study indicate that further study in this area is required; information from the remaining production trials in the FPSR programme will shed light on this matter.

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The welfare of finishing pigs under different housing and feeding systems: 1. liquid versus dry feeding in fully-slatted and straw-bedded housing

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Introduction There is a need to identify finishing systems for pigs that meet the requirements of both pig producers and society. These require that a system is economically efficient, but also takes due account of animal welfare, food safety and environmental considerations. As part of an integrated investigation, this study assessed the health and welfare implications of giving pigs either dry or liquid feed when housed in either fully-slatted or straw-based accommodation.

Materials and methods A total of 1056 Landrace x Large White pigs were selected at 34 kg liveweight between 16/04/02 and 02/07/02. Intakes of 128 pigs were allocated between 4 pens within a single room in either a fully-slatted (FS) or straw-based (ST) building. Two feeding systems, either automated liquid feeding (L) or dry hopper feeding of a pelleted compound diet (D), were replicated between rooms within each housing system, delivering a diet of the same specification. For full housing and diet details see Thompson *et al.* (2004). A blood sample was taken from all pigs at start and at slaughter (104 kg), and from a sample of 6 'focal' pigs per pen at the mid-point (60 kg), for determination of serum acute phase protein concentrations. All incidences of symptoms of ill-health and medicine administration were recorded, and regular detailed observations on focal pigs were made for cleanliness, skin lesions, hock bursitis and behaviour. At slaughter, foot lesions, forelimb osteochondrosis, lung and cardiac lesions and gastric ulceration were scored. Data were analysed as a 2x2 factorial using ANOVA with pen as the statistical unit (N=16 for each main effect).

Results Parameters showing a system difference are presented in Table 1. Mortality was low (L=1.2%, D=0.6%). Removals for health reasons did not differ between feeding systems (L=4.8%, D=6.2%), but significantly more pigs were removed from D for respiratory conditions. Removals for health conditions were higher from the FS system (34 v 13 pigs), with lameness and tail-biting injury being the major reasons. Medicine treatment incidence was higher in L feeding system (352 v 223 pig days), with respiratory conditions and lameness being the major reason, and in ST housing (359 v 216 pig days), with respiratory conditions being the major reason. Tail injury was the major reason for treatment in FS. L pigs and those in ST housing were less clean. ST pigs were more active and spent a significant amount of time investigating and manipulating straw, whereas FS pigs spent less time occupied with the hanging 'toy' provided for them. L pigs were less active and spent less time performing oral behaviours towards other pigs and pen components. Post-slaughter assessment showed that the nature, but not the overall level, of foot damage differed between housing systems. Gastric ulceration scores were lower in L feeding and ST housing systems.

Table 1 Health and welfare measures of finishing pigs in different housing (H) and feeding (F) systems

		Fully Slatted		Straw Based		SEM	Sig.		
		Liquid	Dry	Liquid	Dry		H	F	HxF
Cleanliness score (% clean skin)		82	87	60	76	2.1	***	***	**
% Observed time:	'Sleeping'	65	56	52	49	2.1	***	**	
	Eating	3.9	4.4	4.6	5.0	0.3			
	Drinking	0.4	1.2	0.7	1.2	0.1		***	
Oral behaviour towards:	Straw	-	-	14.0	14.3	0.9	n/a		
	Toy	1.1	1.5	-	-	0.2	n/a	**	
	Other pig	7.0	10.0	7.9	8.8	0.7		**	
	Pen parts	6.9	10.6	5.7	7.6	0.8	*	***	
At slaughter: C-Reactive protein (ug/ml)		80	113	91	93	18.4			
	Haptoglobin (mg/ml)	0.67	0.71	0.39	0.48	0.09	**		
Foot lesions (0-3 scale):	Toe erosion	0.5	0.4	1.2	1.1	0.1	***		
	Heel erosion	1.0	1.3	0.3	0.2	0.1	***		
Gastric ulceration (0-5 scale)		1.7	3.2	0.9	2.8	0.2	**	***	

Conclusions The results show both advantages and disadvantages to each of the housing systems, with the straw-based housing giving better behavioural occupation but poorer hygiene and respiratory health under summer conditions. Liquid feeding showed welfare benefits in behaviour and gastric ulceration but reduced hygiene, especially in straw-bedded housing.

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Thompson, J. E., Matthews, K. R., Taylor, L. and Gill, B.P. 2004. The growth performance, carcase and meat quality of pigs finished under different housing and feeding systems: 1. Liquid versus dry feeding in fully slatted and straw-bedded housing. *Proceedings of the British Society of Animal Science.* Annual Meeting 2004

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The microbial status of the pig and its environment under different housing and feeding systems: 1. liquid versus dry feeding in fully slatted and straw-bedded housing

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Introduction There is a need to identify finishing systems for pigs that meet the requirements of both pig producers and society. These require that a system is economically efficient, but also takes due account of animal welfare, food safety and environmental considerations. As part of an integrated investigation, this study assessed the effects of giving pigs either dry or liquid feed when housed in either fully-slatted or straw-based accommodation on the microbial status of the pig and its finishing environment, with particular reference to gut health and food safety.

Materials and methods A total of 1056 Landrace x Large White pigs were selected at 30-40 kg live weight. Intakes of 128 pigs were allocated between 4 pens within a single room in either a fully slatted or straw-based building. Two feeding systems, either automated liquid feeding or dry hopper feeding of a pelleted compound diet, were replicated between rooms within each housing system, delivering a diet of the same specification (see Thompson et al., 2004). Samples were obtained throughout the trial of feeds and feed components, water and straw, dust, faeces and slurry. Intestinal samples (ileum, caecum and colon) were obtained from two pigs per room at entry and from 6 pigs per pen at slaughter. Caecal samples were taken from all pigs at slaughter. Blood samples were taken from all pigs and examined for the presence of antibodies to *Salmonella* at entry and at slaughter. Microbial enumeration was carried out throughout the trial using selective media, to provide counts of: Total aerobic bacteria (feeds, dust, faeces); Total anaerobic bacteria (feeds, faeces); *Lactobacilli* (feeds, faeces); *Enterobacteriaceae* (feeds, faeces); Coliforms (water, dust) and yeast (feeds, faeces). All samples (except water) were also tested for *Salmonella* contamination, as were the straw samples. At slaughter, samples from the ileum, caecum and colon were tested for the aforementioned bacterial groups with the exception of *Enterobacteriaceae*. Caecal samples were tested for *Salmonella* and colon samples were tested for the presence of *Brachyspira* and *Lawsonia* using PCR. Statistical analysis of microbial counts was performed on log10-transformed data by two-way ANOVA or GLM as appropriate, using Minitab (release 12.1).

Results A natural *Salmonella* infection occurred in one pen, which incidentally provided considerable useful data as it spread throughout the trial. Liquid-fed pigs were generally microbiologically less challenged than dry-fed pigs, despite the higher microbial load of liquid feed. Liquid feeding significantly affected the intestinal microflora while the environmental samples were affected by housing system. The lactic acid bacteria to coliform ratio in the gut was favourably increased (<0.01) by liquid feeding. Pigs on liquid feed were less susceptible to infection by *Salmonella* than those on dry feed (Table 1). *Salmonella* could not be detected in samples of dry and liquid feed and fresh straw bedding taken throughout the trial, suggesting that *Salmonella* entry was with symptomless carrier pigs. Fully slatted housing tended to produce less environmental contamination than straw based housing, as evidenced by the reduced levels of bacterial contamination found in the dust (Table 2). Samples of straw and water were free of contamination and the microbial load of the feeds was within acceptable limits throughout.

Table 1 Percentage of pigs per pen, which tested positive for *Salmonella* at slaughter by housing and feeding system

		Housing System		Feeding System		s.e.d.	P		
	n	Fully Slatted	Straw based	Liquid	Dry		H	F	H x F
Caecal %positive	16	28	34	23	39	7.5		*	
ELISA %positive	16	22	29	16	35	7.3		*	

Table 2 Total aerobic bacteria and coliforms in dust (log10 cfu/g).

		Housing System		Feeding System		s.e.d.	P		
	n	Fully Slatted	Straw based	Liquid	Dry		H	F	H x F
Total aerobes	8	6.91	7.92	7.41	7.44	0.137	*		
Coliforms	8	2.11	3.30	2.72	2.71	0.187	*		*

Conclusions Liquid feed produced an intestinal microflora better able to resist infection with *Salmonella*. The higher microbial load of the liquid feed did not appear to adversely affect the intestinal microflora of the pigs. Liquid-fed pigs carried reduced bacterial numbers. From a bacteriological view, this study showed that a combination of liquid feed and fully slatted housing would provide the safest environment for growing pigs and for food safety.

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Thompson, J. E., Matthews, K. R., Taylor, L. and Gill, B.P. 2004. The growth performance, carcase and meat quality of pigs finished under different housing and feeding system: 1. Liquid versus dry feeding in fully slatted and straw-bedded housing. *Proceedings of the British Society of Animal Science.* Annual Meeting 2004

Environmental impact from pigs finished under different housing and feeding systems: 1. liquid versus dry feeding in fully slatted and straw-bedded housing

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Introduction There is a need to identify pig finishing systems that meet the requirements of both pig producers and society. These require that a system is economically efficient, but also takes due account of animal welfare, food safety and environmental considerations. As part of an integrated investigation, this study assessed the environmental implications (gaseous emissions and waste output and composition) of giving pigs either dry or liquid feed, when housed in either fully-slatted or straw-based accommodation.

Materials and methods A total of 1056 Landrace x Large White pigs were selected at 30-40 kg live weight. Intakes of 128 pigs were allocated between 4 pens within a single room in either a fully-slatted or straw-based building. Two feeding systems, either automated liquid feeding or dry hopper feeding of a pelleted compound diet, were replicated between rooms within each housing system, delivering a diet of the same specification (Thompson et al., 2004). Emissions and wastes were monitored on a room basis to assess the impact of the different feeding treatments on environmental impact. Ventilation rate and ammonia concentration were measured continuously and dust concentration, farm yard manure and slurry weight and volume, and composition were measured fortnightly (Demmers *et al.*, 1999; Takai *et al.*, 1998). The ammonia and dust emissions were calculated from the concentration and ventilation rate.

Results Housing and feeding system had no significant ($P>0.05$) effect on ammonia emission (Table 1). Whilst liquid feeding significantly improved food conversion ratio (Thompson et al., 2004), any shifts in nitrogen (N) excretion may not have been of a sufficient magnitude for the detection of a significant difference in ammonia emission or may have been masked by increased slurry production. The effects of housing might be largely concealed by external conditions, e.g. ambient temperature and hence ventilation rate. However, the use of ambient temperature as a covariate did not change the statistical outcome ($P>0.05$). Neither was there much difference in hygiene score (% of clean skin) or animal activity between the two housing systems. There were no significant effects of housing or feeding treatment on dust concentration and emission. In fully slatted housing Nilsson (1982) showed that some of the suspended dust particles could be contributed to feed, but the majority were pig associated. If pig activity is the overriding factor for dust, this could explain the lack of difference between housing systems in this study. Liquid compared with dry feeding increased effluent production (7.31 v 5.20 litres per pig day; $P<0.001$), but there were no significant effects of feeding treatment on the ammoniacal or Kjeldahl N content of the effluent, hence no significant effect on ammonia emission.

Table 1 Ammonia emission (g NH_3-N.lu^{-1}.hr^{-1}), respirable dust concentration (mg.m^{-3}) and emission (g.hr^{-1}.lu^{-1}) and mean daily ambient temperature (^oC) according to housing and feeding system (mean value from continuous data).

Building type	Feeding system	Ammonia emission	Dust concentration	Dust emission	Daily temperature
Slatted	dry	2.14	2.39	1.25	14.8
Slatted	dry	1.13	3.95	2.34	16.7
Slatted	liquid	1.92	1.23	0.58	13.5
Slatted	liquid	1.88	2.43	1.12	16.7
Straw based	dry	1.23	2.22	1.13	12.9
Straw based	dry	2.64	1.82	1.28	16.2
Straw based	liquid	2.25	1.15	0.67	14.4
Straw based	liquid	1.79	2.46	1.50	16.8

Conclusions There were no significant effects of housing or feeding system on ammonia and dust emission and dust concentration. The mean ammonia emission was 1.87 g NH_3-N.lu^{-1}.hr^{-1} (standard error 0.22; $p=0.72$) and the mean dust emission was 1.23 g.hr^{-1}.lu^{-1} (standard error 0.22; $p= 0.34$).

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Effect of altering grazing interval during the grazing season on grass growth and utilisation and animal performance under rotational grazing by dairy cows

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Introduction Grazed grass is often considered to be one of the cheapest feeds for dairy cows, the cost of grazed grass is largely determined by the yield of herbage produced and the efficiency of utilisation by the grazing animal. Recent farm surveys and an assessment of detailed costings suggest that alternative forages may be cheaper than grazed grass in some situations, particularly if herbage yields are low and utilisation is poor (Kilpatrick *et al.*, 2002). The objective of this experiment was to examine the effect of altering the grazing interval, in a rotational grazing system, on grass growth and utilisation, and on animal performance.

Materials and methods Seventy-six lactating dairy cows (mean calving date, 12 February (s.d.23.7)) were allocated to one of two experimental treatments (normal rotation (NR), and alternative rotation (AR)), with animals balanced for milk composition, milk yield, days in milk, live weight and breed. The experiment involved thirty-nine multiparous dairy cows (Holstein Friesian and Norwegian dairy cattle (NRF)) and thirty-seven primiparous animals (Holstein Friesian, NRF and crossbreds). The experiment commenced on 30 April, at which point animals were grazing full time, and finished on 8 October. Both treatments were based on a rotational grazing system, with cows given access to fresh pasture daily, following evening milking. With treatment NR a 20-day rotation was adopted in early season, increasing to twenty-three days in mid season and twenty-six days in late season. With treatment AR, an initial 20-day rotation was followed by a twelve day rotation, three eight day rotations and two twelve day rotations. Thereafter the AR followed the same grazing pattern as for NR in mid and late season. Concentrates were offered at 2kg/cow/day from 3 May until 26 Sept, and subsequently increased to 3kg/cow/day until the end of the study. Stocking rates with both treatments were equal throughout the study, namely 6.3, 5.5 and 4.9 cows/ha in early, mid and late season, respectively. The shorter cycle lengths within treatment AR were achieved by increasing the area cows grazed each day. Pre- and post-grazing sward heights were measured daily using a rising plate meter, while a 'pluck' sample of offered pasture was analysed weekly for crude protein and metabolisable energy (ME) concentration using NIRS. Throughout the study, milk yields and live-weights where recorded daily, body condition score weekly and milk composition fortnightly. Production data were analysed using ANOVA, with the appropriate pre-experimental data being used as covariates.

Results Mean pre- and post-grazing sward heights during the study were 10.96 and 5.91 cm for NR, and 9.27 and 5.66 cm for AR. The mean pre-grazing herbage yields (>4cm) were 4399 (s.d.726.3) and 4202 (s.d.998.0) kg DM/ha for NR and AR respectively, while available herbage (>4cm) for NR and AR were 21.7 (s.d.3.82) and 23.2 (s.d.6.29) kg DM/cow/day, respectively. Mean post-grazing herbage yields were 2885 (s.d.758.3) and 2812 (s.d.561.2) kg DM/ha for NR and AR respectively. The herbage grazed within NR and AR had a mean crude protein content of 193 (s.d.2.6) and 202 (s.d.2.4) g/kg DM respectively, and a mean predicted ME concentration of 10.8 (s.d.0.4) and 10.9 (s.d.0.5) MJ/kg DM respectively. Milk production data, presented in Table 1, represents mean data for the duration of the study. Milk yield was significantly higher with NR compared to AR ($P<0.01$), with this difference in yield arising from approximately week 3 of the study onwards. Grazing system had no significant effect on either milk fat, protein or lactose contents ($P>0.05$), or on milk fat plus protein yield ($P=0.056$). In addition, treatment had no significant effect on either liveweight or condition score, as measured at the end of the study ($P>0.05$).

Table 1 Effect of altering grazing interval on dairy cow performance

	Normal rotation	Alternative rotation	SEM	Sig
Milk yield (kg/day)	18.2	17.0	0.27	**
Milk composition				
Fat (g/kg)	37.2	38.4	0.53	NS
Protein (g/kg)	32.7	32.9	0.27	NS
Lactose (g/kg)	47.3	47.0	0.13	NS
Milk fat + protein yield (kg/day)	1.26	1.20	0.021	NS
Final live weight (kg)	496	502	6.6	NS
Final body condition score	2.4	2.5	0.03	NS

Conclusions Within treatment AR, the shorter grazing interval reduced grass growth and the yield of grass pre-grazing and resulted in swards being grazed to lower residuals. As a consequence animal performance was reduced despite higher herbage quality with treatment AR, particularly in mid and late season.

Reference

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A comparison of the first lactation performance of Holstein-Friesian and Norwegian dairy cows on Northern Ireland dairy farms

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Introduction Although significant progress in milk production efficiency has been achieved in recent years with the Holstein-Friesian breed, it is now realized that dairy cow breeding programmes with a primary focus on yield have resulted in increased levels of infertility, and reduced health and longevity. In contrast, Norwegian dairy cattle (NRF) have been bred within multi-trait selection programmes for approximately 25 years. As a consequence of the latter, the incidence of mastitis within Norway continues to decline, while fertility levels are increasing. In view of these positive trends within the NRF population in Norway, two studies were established to evaluate Norwegian dairy cattle under Northern Ireland conditions. The first of these was conducted at the Agricultural Research Institute of Northern Ireland (Keady and Mayne, 2002), while the second was established on 19 commercial dairy farms. The aim of the latter was to compare the production, fertility and health of animals of the NRF and Holstein-Friesian dairy breeds across a range of production systems.

Material and methods Two hundred and fifteen Norwegian dairy cattle were imported into Northern Ireland as maiden heifers (3 – 15 months old), and placed on 19 commercial dairy farms (11 or 12 animals/farm). These animals had a mean total merit index (TMI) of 10.1 (s.d. 1.69). An equal number of 'home bred' Holstein-Friesian (HF) animals of similar ages were selected on each farm. More than 25 sires were represented within each breed. On each individual farm, animals of both breeds were subject to the same rearing and management regimes pre-calving, and to the same feeding and management regimes post-calving. However each farm followed its own rearing, feeding and management regime. The 19 participating farms were selected to cover a range of production systems, and represented both Spring and Autumn calving herds. All farms participated in monthly milk recording schemes, with all other records maintained by the farmers. A total of 170 HF animals and 179 NRF animals have now completed their first lactation. Animal performance data were analysed by ANOVA, with the effect of 'farm' excluded from the analysis due to the incomplete nature of the dataset. Fertility data were tested using the Chi Square test. Performance of animals of each of the two breeds are presented below.

Results Data presented in Table 1 indicate that the NRF breed had fewer calving difficulties compared to the HF breed ($P<0.001$), while significantly more HF calves were born dead ($P<0.01$). Milking behaviour scores, recorded during the first 48 hours post calving, indicated that NRF animals were more temperamental at milking ($P<0.001$). Breed had no significant effect on 305-day milk yields ($P>0.05$). Milk fat content was unaffected by breed, while milk protein content was significantly lower for animals of the HF breed ($P<0.001$). Full lactation milk yields were not significantly affected by treatment ($P>0.05$). Conception rates to first service were 54% and 42% for animals of the NRF and HF breeds respectively ($P<0.05$).

Table 1 First lactation performance of dairy cows of two different breeds on 19 commercial dairy farms

	NRF	HF	SEM	*SIG*
Peri-calving measurements				
Calving difficulty: scale 1 (unassisted) to 5 (caesarean)	1.4	1.9	0.06	***
Calves born dead (%)	4.9	13.1	2.0	**
Milking behaviour: scale 1 (calm) to 4 (difficult to milk)	2.1	1.6	0.06	***
Production				
305 day milk yield (kg)	5632	5894	98.8	NS
305 day fat content (g/kg)	38.9	38.3	0.29	NS
305 day protein content (g/kg)	32.9	32.2	0.15	***
Days in milk	320	312		
Full lactation concentrate input (kg fresh)	1508	1372	43.8	*
Full lactation milk yield (kg)	5983	6218	124.3	NS
First lactation fertility data				
Conception to 1st service (%)	54	42		*

Conclusions While animals of the NRF breed had fewer calving difficulties and more calves born alive compared to the Holstein breed, milk yield tended to be lower for the former. Animals of the NRF breed had a 12% higher conception rate to first service than animals of the HF breed.

Acknowledgement This study was co-sponsored by DARDNI and AgriSearch.

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The effect of inclusion of a range of supplementary feeds on milk yield and composition of grazing dairy cows

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Introduction With increasing Holsteinisation of the dairy herd, the milk production potential of dairy cows has increased substantially over the past two decades. This development presents new challenges for managing dairy cows during grazing, particularly where the objective is to maximise the proportion of energy in the diet derived from forage (Mayne and Peyraud, 1996). The objective of the current study was to explore forage supplementation strategies to maintain high milk yields from grass and forage in dairy cows during the grazing season. A second objective of the study was to examine the effect of concentrates of contrasting degradability on milk production.

Materials and methods Twenty four spring calving dairy cows were used with five periods, each of 4 weeks and six treatments in a partially balanced, change-over design experiment commencing on 9 May. The treatments were based on a range of supplements including: maize silage (MS); whole crop wheat silage (WS); grass silage (GS); rapidly available energy concentrate (RC); slowly available energy concentrate (SC); and a control which was unsupplemented (C). The components of the SC concentrate were sugar beet pulp, citrus pulp, maize gluten feed, soyabean meal, soya hulls, rape meal, vitamin/minerals, molasses, Megalac and urea included at 150, 190, 125, 175, 242, 25, 40, 30, 20 and 3 g/kg fresh respectively. The RC concentrate included barley, wheat, soyabean meal, sucrose, wheat feed, rape meal, vitamins/minerals and molasses at 200, 255, 200, 125, 100, 50, 40 and 30 g/kg fresh respectively. Forage supplements were offered indoors *ad libitum*, for 2h after the morning milking. Cows on concentrate treatments (RC + SC) received the allocated concentrate in the milking parlour twice daily (4.5 kg fresh/cow/d). The concentrate supplemented and unsupplemented cows returned to grazing immediately after milking, whereas cows receiving forage supplements were retained after morning milking to access allocated forage supplement. All cows were rotationally grazed in a paddock system, with a target residual sward height measured using a rising plate meter of 5-6 cm, with cows offered new paddocks after pm milking. Forage supplement intake was measured using a Calan gate system with fresh forage offered daily. Milk composition was measured on 2*3 day composite samples collected in the final week of each period and milk yields were recorded daily.

Results Animal performance data are presented in Table 1. Cows offered concentrate treatments produced the highest milk yield, protein yield, lactose yield, fat + protein yield and overall milk energy output. The increased milk yield with the MS treatment approached significance compared to the GS diet and was significantly greater than WS and C. Cows offered the MS and WS treatments had the highest milk butterfat contents. Protein content was significantly higher with the MS, RC and SC treatments than for the GS treatment, with the MS treatment also being significantly higher than WS. Concentrate type had no significant effect on milk yield, milk component or milk energy outputs.

Table 1 Effect of a range of supplement treatments on performance of grazing dairy cows

		Forage			Concentrate			
	Control	Grass silage	Maize silage	Wheat Silage	Rapid energy	Slow energy	Sed	Sig
Supplement fresh int. (kg/day)	0.0^{a}	17.5^{d}	21.6^{e}	12.0^{c}	4.6^{b}	4.5^{b}	1.26	***
Supplement DMI (kg DM/d)	0.00^{a}	2.99^{b}	6.30^{d}	3.61^{bc}	3.94^{c}	3.92^{c}	0.367	***
Milk yield (kg/d)	17.1^{a}	18.4^{ab}	19.8^{b}	18.0^{a}	21.9^{c}	21.3^{c}	0.74	***
Butterfat (g/kg)	39.8^{ab}	39.9^{ab}	41.5^{b}	40.2^{ab}	38.3^{a}	38.6^{a}	1.06	*
Protein (g/kg)	32.1^{abc}	31.4^{a}	32.8^{c}	31.7^{ab}	32.2^{bc}	32.4^{bc}	0.38	**
Lactose (g/kg)	46.0^{a}	47.0^{b}	47.1^{bc}	46.9^{ab}	47.9^{c}	47.0^{bc}	0.45	**
Fat yield (g/d)	672^{a}	725^{a}	823^{b}	714^{a}	831^{b}	812^{b}	32.9	***
Protein yield (g/d)	539^{a}	568^{a}	640^{b}	559^{a}	704^{c}	685^{bc}	22.9	***
Fat + protein yield (g/d)	1210^{a}	1293^{a}	1463^{b}	1273^{a}	1536^{b}	1497^{b}	52.9	***
Milk energy output (MJ/d)	51.7^{a}	55.7^{a}	62.4^{b}	54.8^{a}	66.2^{b}	64.2^{b}	2.30	***

Means within rows with same superscript are not significantly different

Conclusions The results of the present study suggest that maize silage can be an effective supplement to grazing dairy cows compared to whole crop wheat silage and grass silage, being reflected in an increased milk yield and increased yield of milk components, therefore resulting in a greater milk energy output. Concentrate type had no significant effect on milk yield or outputs of milk components or milk energy but did increase performance compared to forage supplements.

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The effect of stage of maturity and method of preservation of processed whole-crop wheat on the intake and milk production in dairy cows

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Introduction The use of a forage processor, which is fixed within the forage harvester and cracks the grains of whole-crop wheat (WCW) at harvest, has been shown to increase the digestibility of the starch component and improve the efficiency of forage utilisation in dairy cows (Jackson *et al.*, 2002). This allows the wheat to be harvested over a much wider harvest window, although the optimum stage of maturity at which processed WCW should be cut is unclear. In addition, at the very high dry matter (DM) values that the forage processor allows WCW to now be harvested, the use of urea as a preservative may not be required. The objective of the current experiment was, therefore, to compare WCW harvested at different stages of maturity and investigate the effect of using a urea-based preservative on high DM processed WCW, on the performance of dairy cows.

Materials and methods A conventionally managed crop of winter wheat (*c.v.* Consort) was harvested at three target DM values; 450g/kg, 700g/kg and 850g/kg. There were four dietary treatments: WCW harvested at approximately 450g DM/kg, preserved by fermentation and treated with an inoculant/enzyme additive (Whole Crop Gold, Biotal Limited, Cardiff, UK; F-45), WCW harvested at approximately 700g DM/kg (U-70) or 850g DM/kg (U-85) and preserved using a urea + urease product (Home n'Dry, Volac Limited, Royston, UK) or WCW harvested at approximately 850g DM/kg and ensiled with no additive (C-85). Forty-four Holstein-Friesian dairy cows that were on average 38 days into lactation were allocated to one of the four treatments. Forages were mixed with first cut grass silage in the ratio of 1: 2 (DM basis) grass silage: WCW respectively, and offered at a rate of 1.05 of *ad libitum* intake. In addition all cows were supplemented with 2 kg/day of rapeseed meal, 1.4 kg/day of molassed sugarbeet pulp and 0.6 kg/day of lactose mixed with the forage component and with 6.5 kg/day of a standard concentrate (DM 898 g/kg, ME 13.6 MJ/kg DM and crude protein 247 g/kg DM) fed through out-of-parlour feeders. Milk yield was recorded daily and samples taken and analysed weekly whilst intake was recorded daily. Animals were weighed and condition scored weekly and blood sampled at 11:00 h at the start and during weeks 3, 8 and 13 of the experimental period. Results were analysed as a randomised block design.

Results The DM content of the four forages was similar to that predicted at 472, 747, 823 and 850 g/kg. Crude protein content was highest in the U-70 and U-85 treatments (average of 143 g/kg DM) and lowest in the C-85 forage at 98 g/kg DM. Fibre levels, measured as neutral detergent fibre (NDF), were highest in the two mature WCW forages (U-85 and C-85) at approximately 325g/kg DM and lowest in the U-70 treatment at 288g/kg DM. Starch levels were lowest in the F-45 forage at 370g/kg DM and highest in the three mature WCW forages, ranging from 442g/kg DM in the C-85 to 416g/kg DM in U-85, whilst the U-70 forage had an intermediate value. Forage DM intakes averaged 13.4 kg/d and were not significantly different between treatments. Milk yield was higher for animals fed the U-70 forage than those fed F-45 or C-85. There were no significant differences between treatments in milk constituent concentration (g/kg) or yield (kg/d), average live-weight or condition score. Blood urea concentrations (mmol/l) were significantly higher for animals' fed either of the diets harvested at 850g DM/kg.

Table 1 Effect of stage of maturity and method of preservation of processed WCW on animal performance

	F-45	U-70	U-85	C-85	s.e.d	Sign.
Forage DM intake (kg/d)	13.4	12.8	12.9	14.6	0.82	ns
Milk yield (kg/d)	32.3[a]	34.8[b]	33.5[ab]	32.1[a]	0.99	*
Fat (g/kg)	40.6	37.9	39.5	40.0	1.25	ns
Protein (g/kg)	33.5	32.3	32.9	33.0	0.67	ns
Fat yield (kg/d)	1.32	1.32	1.32	1.28	0.062	ns
Protein yield (kg/d)	1.09	1.12	1.10	1.05	0.044	ns
Live-weight (kg)	628	625	610	635	20.8	ns
Condition Score	2.85	2.75	2.64	2.74	0.150	ns
Mean plasma urea (mmol/l)	5.83	6.06	6.64	6.99	0.294	**

[a] within a row, means without a common superscript letter differ ($P<0.05$)

Conclusions Forage DM intake was not significantly different between treatments. Average milk yield in cows fed the U-70 treatment was significantly higher than cows fed either F-45 or C-85 whilst milk fat and protein concentrations were similar across all treatments. It is concluded that milk yield (kg/d) was highest when WCW was harvested at a DM of 700 g/kg and urea-treated, and that there was no significant effect on performance by adding a urea-based preservative at a DM of 850 g/kg.

Acknowledgements We are grateful to the Milk Development Council for funding this project.

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The effect of dietary lipid content and composition on the milk fat iodine value of dairy cows

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Introduction Iodine value (IV) indicates the degree of unsaturation of milk fat, thus reflecting the presence of long chain unsaturated fatty acids (LCUFA), especially C18:1*c.* The higher the IV the greater the degree of unsaturation. Changes in dietary lipid content and composition can have a major effect on the IV of milk fat. The principal fatty acid in the forage component of the diet, namely grass or grass silage, is C18:3 (Murphy, 2000) while concentrate supplements contain varying proportions of C18:1 or C18:2 fatty acids. LCUFA undergo hydrolysis and biohydrogenation in the cow's rumen producing mainly C18:0, the majority of which is converted to C18:1*c* by the desaturase enzyme systems, mainly in the mammary gland (Murphy, 2000). This experiment aimed to examine the relationship between milk fat IV and dietary lipid content, composition and diet type.

Materials and methods Twenty four Holstein/Friesian dairy cows were randomly allocated to six dietary treatments in an incomplete changeover design of 4 periods, each of 4 weeks duration. The dietary treatments were T1**:** 24 hr grass silage + 7 kg/d standard concentrate (STC); T2: 24 hr grass + 3 kg/d STC; T3**:** 12 hr grass + 12 hr grass silage + 5 kg/d STC; T4: 24 hr grass silage + 3 kg/d high-lipid concentrate (HLC) + 4 kg/d STC; T5**:** 24 hr grass + 3 kg/d HLC; T6: 12 hr grass silage + 12 hr grass + 3 kg/d HLC + 2 kg/d STC. Cows were housed indoors and grass was zero-grazed to facilitate intake measurements. All dietary components and milk were sampled weekly, lipid was extracted from freeze-dried forage samples, fresh concentrate and milk samples, and fatty acid methyl esters (FAME) quantified by gas chromatography (Fearon *et al*., 1994). Milk fat IVs and dry matter (DM) contents of the dietary components were determined. A stepwise regression analysis procedure was used to examine the relationship between milk fat IV and dietary lipid content, composition and diet type, with additional variables added to the model until no further improvement in fit was obtained at the 5% level of significance.

Results Based on dietary intake values, Equation 1 describes the relationship between milk fat IV and the dietary lipid content, composition and diet type (Table 1). The provision of grass via zero-grazing in this study resulted in lower milk fat IVs compared to those resulting at pasture in previous work.

Equation 1 $IV = -0.177\ C\ Unsat + 0.003\ C\ L + 0.177\ C\ 18 - 0.031\ S\ Unsat + 0.004\ G\ L + 0.030\ S\ 18 + 17.52$
$R^2 = 0.798$ [The notations used and statistical significance are explained in Table 2]

Table 1 Total lipid (g/kg DM) and total C18 fatty acid content (g/kg total fatty acids) of the dietary components and animal intake values (DMI kg/day) for each component within the six dietary treatments (n =96)

	Total lipid	Total C18 fatty acids	Total unsaturated fatty acids	Dietary Intake (kg/cow/day)					
				T1	T2	T3	T4	T5	T6
Silage	5.43	851	842	11.24	-	7.54	11.04	-	7.63
Grass	4.42	851	842	-	14.73	9.1	-	15.48	9.43
HLC	11.92	895	879	-	-	-	3.49	3.49	3.49
STC	2.06	866	851	6.1	4.59	5.22	1.74	-	0.87
Milk fat IV (g I_2/100g fat)				26.1	30.3	29.3	33.1	39.7	33.6

Table 2 Equation variables, standard errors (se) and significance of variables in Equation 1

Shorthand notation	Equation variable	Se	Significance
C *Unsat*	Unsaturated fatty acids in concentrate (g/d)	0.035	***
C L	Total lipid content in concentrate (g/d)	0.003	***
C 18	Total C18 fatty acids in concentrate (g/d)	0.035	***
S Unsat	Unsaturated fatty acids in silage (g/d)	0.013	**
G L	Total lipid content in grass (g/d)	0.001	***
S 18	Total C18 fatty acids in silage (g/d)	0.013	**

Conclusions Lipid content and composition of the concentrate provided the most weight to the relationship between milk fat IV and dietary lipid composition and type. The interpretation of the individual coefficients, for example *C unsat.* is not possible due to the inter-correlation between the coefficients in the equation. This equation may have the potential to predict milk fat IV when other forage and concentrate compositions are offered. The equation has not however taken into consideration the effects of other factors such as stage of lactation and the breed of cow.

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Incidence of pathogens involved in clinical cases of mastitis and the effectiveness of differing antibiotics in specific mastitis pathogens

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Introduction Mastitis is one of most frequent and costly diseases encountered on dairy farms. In 1998 mastitis costs UK dairy farmers approximately £80 million a year and this figure increases to over £100 million when further associated losses such as somatic cell count (SCC) penalties, antibiotic residue penalties and reduced cell count and bacteria count payments are accounted for. In the 1980's and 1990's there has been a continuing increase in the incidence of environmental mastitis and especially due to E coli (Brand, 1999),. Increasing SCC levels are set against a background of emphasis on higher milk price for low SSC milk by purchasers has led to the need to increase milk price by reducing losses from high SCC levels. The aim of the study was to monitor bulk milk SCC levels in milk supplied to a milk producer co-operative over a 12 month period and select a sub-sample of milk producers with high SCC, analyse the clinical incidence of mastitis, establish the pathogens involved and their response to antibiotics.

Materials and methods 2150 bulk milk SCC levels were monitored over a 12 month period. A sub-sample of 10 commercial dairy farms were selected at random according to SCC levels and matched according to herd size, housing type, feeding levels and milk yield. 410 milk samples were collected from cows exhibiting clinical symptoms of mastitis over a 12 month period. The organism(s) responsible for mastitis were initially detected by spreading 0.2ml of milk from the sample under test across the surface of a selective/diagnostic culture media and incubating the plates at 37 C for 24/48 hrs. To establish differing pathogens; Baird Parker medium was used for *Staphlococcus aureus*, Edwards Medium for *Streptococci agalactiae, dysgalactiae and uberis* and Macconkey Agar to detect *E coli*. Tellurite Glycine was used as an inhibitor and sodium pyruvate as selective growth stimulant. The determination of the sensitivity of the causative organism to antibiotics was carried out using 'Multidiscs' of sterile filter paper with projecting arms. Plates were incubated for 24/48 hrs at 37 C and the width of the zone measured to indicate the effectiveness of the antibiotic. Data was normally distributed and analysed by ANOVA for effect of farm, antibiotic, housing, bedding frequency, milking routine and casual pathogen.

Results

Table 1. *Effective distance (cm) of inhibition of E coli, S. aureus, S. uberis and mean distance according to antibiotic type*

Antibiotic	E coli	S. aureus	S. uberis	Mean
Streptomycin	0.0	0.70	0.66	0.66
Cloxacillin	0.07	0.81	0.00	0.45
Furazolidone	0.10	0.81	0.41	0.55 [b]
Neomcyin	0.40	0.37	0.40	0.37 [c]
Synulox	0.80	0.93	0.80	0.88 [a]
Oxytetracillin	0.40	0.70	0.30	0.30
Rifampicin	0.40	0.00	0.70	0.55
sem	0.067	0.100	0.104	0.057
Significance	NS	NS	NS	***

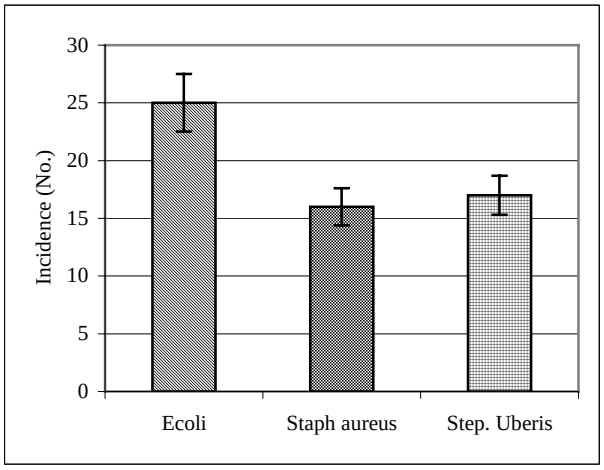

Figure 1. *Incidences* of *E coli, S. uberis and S. aureus* over a 12 month period

There was a significantly greater mean effective area around the antibiotic disks impregnated with Synulox compared with Furazolidone and Neomcyin. while Furazolidone was found to be more effective than Neomcyin. *E Coli* was found to be present in significantly more cases of clinical mastitis compared with *S. aureus* and *S. uberis*.

Discussion The incidence of *E Coli* was though most likely to be due to sample contamination. In terms of antibiotic effectiveness, of the antibiotics tested there was found to be no significant difference between antibiotics in the treatment of *E coli, S. aureus and S. uberis* individually. However, Synulox was found to be significantly more effective overall.

Conclusion Over all the mastitis causing pathogens, Synulox was found to be the most effective, significantly more effective compared with Furazolidone, while Furazolidone was found to be more effective than Neomcyin.

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Direct effects of bioactive forages in sheep infected with *Trichostrongylus colubriformis*.

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Introduction Parasitised sheep that consumed bioactive forages, i.e. forages that contain anthelmintic compounds, showed a lower level of parasitism than sheep grazing on grass/clover pastures (Marley *et al*, 2003). This may be due to direct anthelmintic effects of the bioactive forages or indirect nutritional effects, e.g. mediated through an increase in protein availability. Extra protein could improve the host's ability to mount an effective response towards gastrointestinal parasites (Coop and Kyriazakis, 1999). The aim of this experiment was to investigate whether a two-week consumption of forages that contain potential anthelmintic compounds, have a direct anthelmintic effect towards i) an established *Trichostrongylus colubriformis* population and/or ii) incoming *T.colubriformis* larvae.

Materials and Methods Sixty Texel x Grayface parasite naive sheep were infected with 8,000 *T.colubriformis* infective larvae on day 1 of the experiment. Up to day 28, sheep were grazing on a parasite clean grass/clover pasture. On day 28, they were allocated to 10 groups (n=6) based on their faecal egg counts (FEC) and liveweight, and were moved to the experimental plots for two weeks. The experimental plots (10 plots, two replicates for each forage species) consisted of five forage species: *Lotus pedunculatus* (lotus), *Onobrychis viciifolia* (sainfoin), *Chicorium intybus* (chicory), *Hedysarum coronarium* (sulla) and *Lolium perenne/Trifolium repens* (grass/clover). On day 35 of the experiment, sheep were dosed with a second dose of 8,000 *T.colubriformis* infected larvae, to investigate the effects of bioactive forages on incoming larvae, and were killed on day 42. FEC were monitored throughout and were analysed with ANOVA for repeated measurements, with forage species and plot replicates as factors. Adult and immature nematodes recovered from the gastrointestinal tract of sheep and liveweight gain of sheep were analysed by ANOVA, with the same factors as the FEC. FEC and worm counts were log (x+1) transformed prior to analysis.

Results All measurements obtained from the replicates of the same forage species were similar. Figure 1 shows that sheep grazing on lotus had lower FEC compared to sheep grazing on grass/clover between days 31-42 ($P<0.01$). Sheep grazing on lotus and grass/clover grew 320 (se: 26.5) g per day, whereas sheep grazing on chicory had the lowest liveweight gain, at 170 (se: 27.1) g per day (sed: 55, $P<0.05$). The growth of sheep grazing on sainfoin and sulla was 220 (se: 25.6) and 260 (se: 22.7) g per day respectively. Although immature and adult parasite burdens were lower in sheep grazing chicory than any other forage, the difference observed was not significant (Figure 2).

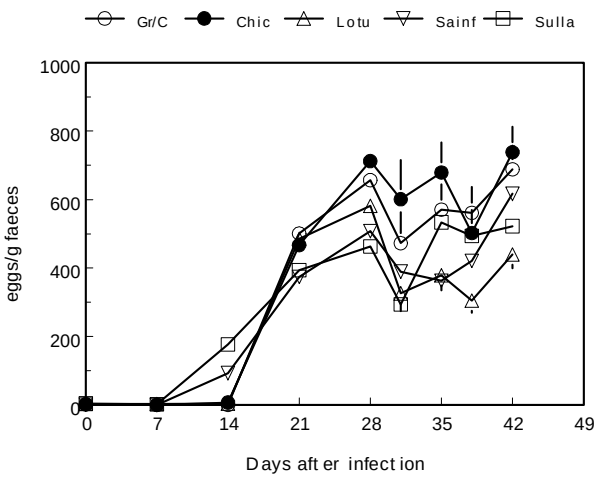

Figure 1 Backtransformed FEC of sheep grazing on five different forages, with 95% confidence intervals.

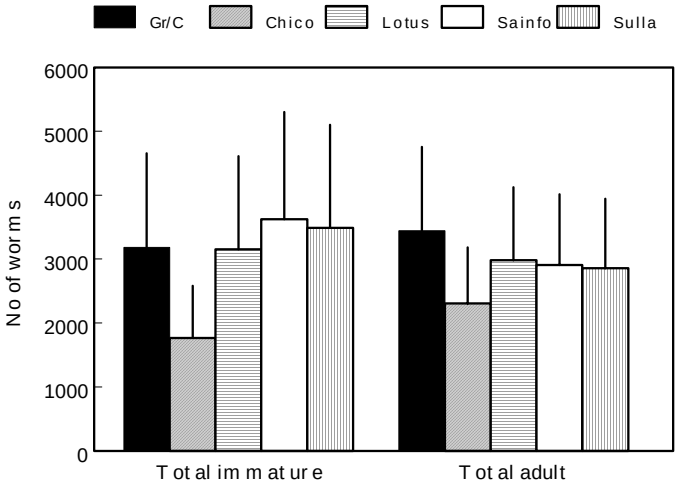

Figure 2 Backtransformed immature and adult worm burdens of sheep grazing on five different forages, with the upper limits of 95% confidence intervals

Conclusion Grazing on bioactive forages for a period of only two weeks did not directly affect the viability of adult and the establishment of infective *T.colubriformis* worms. The number of eggs excreted per g faeces was lower in sheep grazing lotus compared to those grazing grass/clover, which implies a possible direct anthelmintic effect of lotus on the fecundity of female nematodes. It is possible that a longer grazing period on the bioactive forages could benefit sheep parasitised with *T.colubriformis* either through a long-term direct anthelmintic effect or an indirect nutritional effect.

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Ingestion of rabbit faeces by livestock – potential for inter-species disease transmission

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Introduction In grazing systems livestock contact with faeces and the faecal-oral route is a common mode of parasite transmission (Hutchings *et al.* 2003). Quantifying the faecal-oral route of transmission is thus central to predicting the force of infection of numerous diseases experienced by grazing livestock. Here our overall aim is to quantify the rate of faeces ingestion and thus disease risk by grazing herbivores using the example of rabbits (*Oryctolagus cuniculus*) and the risk of paratuberculosis (*Mycobacterium avium* subsp. *paratuberculosis*) they pose to ruminants. The study had the secondary aims of determining the effects of level of contamination and sward height on the rate of faeces ingestion.

Materials and methods Ten Holstein calves of 10 weeks old and ten Texel x Greyface lambs of 20 weeks old were used in the study. The calves were run as a group and individually penned for presentation of their treatments and the lambs were individually penned for the duration of the experiment. The animals were fed *ad lib* on high quality pelleted feed (and hay for the calves) which was removed for presentation of the treatments. All animals had been recently weaned and were accustomed to grazing from the sward trays (54x54cm for calves and 36x21cm for lambs) prior to the experiment. Nine sward treatments were created through three sward heights (3, 6 & 12cm) and three levels of contamination (120, 240 and 480 rabbit faecal pellets/m^2). Three replicates of each treatment were presented to each animal. The animals were allowed to graze for 60 (90 for lambs) bites or until five minutes had elapsed. Each animal was presented with three treatments in succession on each day. Once the trays had been removed from the animals the number of pellets remaining, the occurrence (or lack) of an ingestion event (i.e. where one or more pellets are ingested from a tray), the number of bites taken, the time elapsed (seconds) and the average grazing depth (cm above soil surface) were recorded. Residual maximum likelihood (REML) was used to estimate the mean values for grazing parameters (bite rate and grazing depth). A Bernoulli variable within a generalised mixed model, iterative reweighted residual maximum likelihood (IRREML), with a logit link transformation was used to look at the incidence of ingestion and the number of pellets ingested relative to the level of contamination.

Results *Calves* Overall the calves ingested 1.27% of the faecal pellets presented to them, with ingestion events occurring from 33.9% of the trays. Ingestion events increased as the level of contamination increased ($P<0.001$). There was no significant effect of level of contamination on the proportion of pellets ingested ($P>0.05$) nor on bite rate or grazing depth ($P>0.1$ for both). Sward height had no significant effect on the number of ingestion events ($P>0.05$). Sward height did have a significant effect on the proportion of faecal pellets ingested ($P<0.05$), greater numbers of pellets were ingested at 3cm than both 6 and 12cm.
Lambs Overall the lambs ingested 0.476% of the faecal pellets presented to them, with ingestion events occurring from 8.89% of the trays. Level of contamination had no significant effect on the number of ingestion events ($P>0.05$), however the number of pellets ingested decreased as the level of contamination increased ($P<0.05$). Bite rate decreased as level of contamination increased ($P<0.01$).

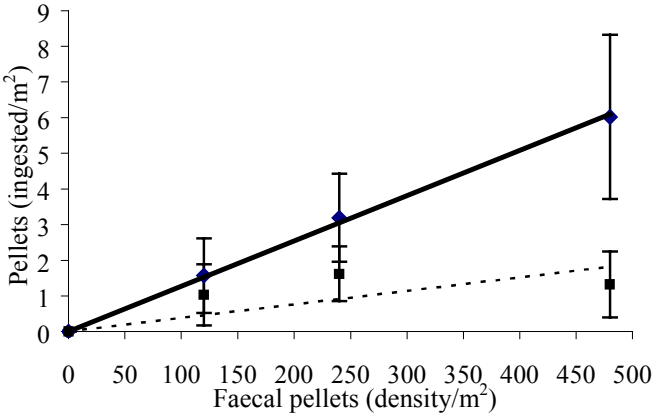

Fig. 1. Mean number of pellets ingested per m^2 at each faecal pellet density (m^2) (with 95% confidence limits) for cattle (♦) and sheep (■). Solid line denotes simple linear regression for cattle ($y = 0.013x$; $r^2 = 0.999$), broken line denotes simple linear regression for sheep ($y = 0.004x$; $r^2 = 0.271$).

Conclusions The results of this study show that a high number of rabbit faecal pellets are ingested by grazing herbivores and therefore rabbits should not be discounted as a possible source of infection for disease. Rate of ingestion is proportional to the level of environmental contamination for cattle, which show no behavioural avoidance of rabbit faecal pellets while grazing. Sheep are better able to avoid ingestion of rabbit faeces than cattle. The probability and rate of ingestion of rabbit faecal pellets, and therefore parasites, is affected by sward characteristics (sward height and level of contamination).

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The use of chicory to control parasitism in organic lactating ewes and their lambs

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Introduction Under organic regulations, farmers in the uk are allowed to drench periparturient ewes with an anthelmintic drug before returning them to pasture. Although such practice is against the principles of organic farming, it is allowed as it reduces parasite contamination of the pastures and consequently reduces the risk of parasitism in growing lambs. Alternatives to control parasitism, which do not jeopardise the health and welfare of grazing ruminants and also minimise anthelmintic input in organic systems are currently being investigated. Grazing bioactive forages, such as chicory has resulted in a lower level of parasitism than sheep grazing on grass/clover pastures (Marley *et al*, 2003). The objective of this experiment was to investigate whether grazing on chicory can affect the epidemiology of gastrointestinal parasitism, so that control of sub-clinical parasitism could be achieved without the use of anthelmintics.

Materials and methods Fifty-six twin-rearing, certified organic Shetland cross ewes, which carried a natural mixed parasite infection were used in this 2x2 factorial experiment, with forage species and anthelmintic drench as the two factors. Half of the ewes were drenched with a broad spectrum anthelmintic (200 μg per kg bodyweight) within one day after parturition, whereas the rest remained undrenched. Following parturition, ewes with their twin lambs were moved onto parasite clean pastures of either grass/clover or chicory (two replicates for each treatment; groups of ewes were balanced for faecal egg counts (FEC)). The four treatment groups consisted of either drenched or undrenched ewes that grazed on either grass/clover or chicory pastures. Ewes and lambs remained on the experimental plots until weaning. FEC of ewes and lambs were monitored throughout and were analysed by ANOVA for repeated measurements. FEC were log (x+1) transformed prior to analysis. Liveweight gain of lambs was monitored and analysed by ANOVA.

Results All measurements obtained from the replicates of the same treatment were similar. Undrenched ewes grazing chicory had similar FEC to undrenched ewes grazing grass/clover; ewes drenched with anthelmintic had low FEC and were similar grazing grass/clover or chicory (Fig 1). FEC of lambs from undrenched ewes, which grazed on chicory were lower than those grazing on grass/clover plots, whereas FEC of lambs from drenched ewes grazing chicory or grass/clover were very low (Fig 2). Lambs reared by drenched ewes had higher weight gain than lambs reared by undrenched ewes (269 vs 240 g per day, sed: 7.0; P<0.001). In addition, lambs grazing on chicory showed higher liveweight gain than lambs grazing on grass/clover (265 vs 244 g per day, sed: 7.0; P<0.001).

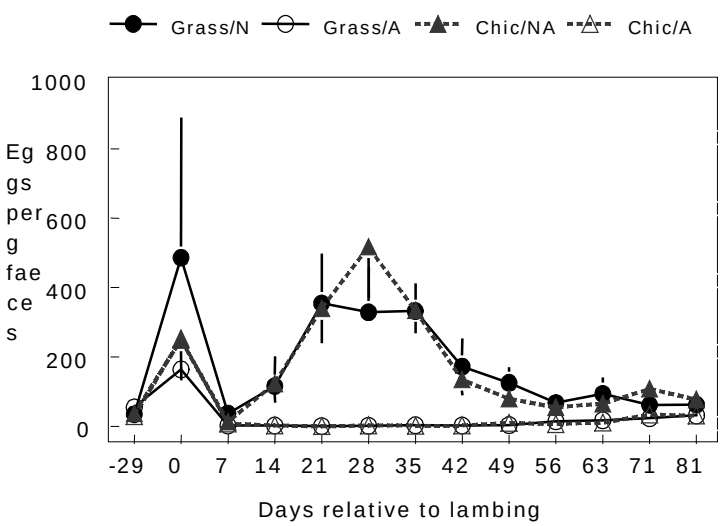

Figure 1 Backtransformed FEC of drenched (A) or undrenched (N) ewes grazing either on grass/clover or chicory pastures, with 95% confidence intervals.

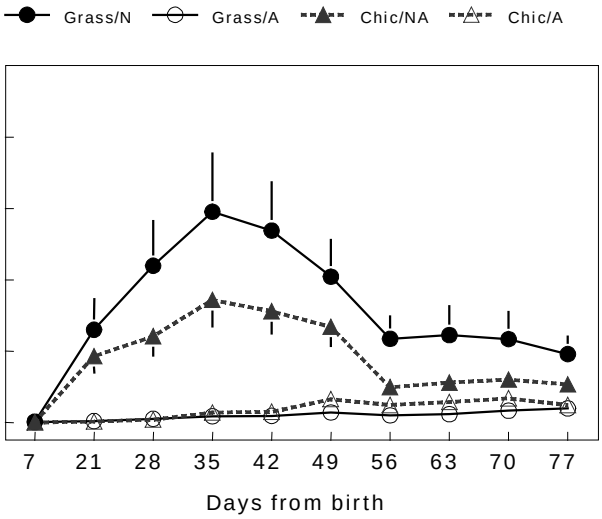

Figure 2 Backtransformed FEC of lambs grazing on either grass/clover or chicory pastures, with 95% confidence intervals

Conclusion Grazing on chicory did not affect the level of parasitism in periparturient ewes. However, lambs reared by ewes that were grazing on chicory showed lower FEC and higher liveweight gain compared to their counterparts reared by ewes grazing on grass/clover. The low FEC of the former lambs could be attributed to either an effect of chicory against incoming parasites, and for this reason this was not observed in the ewes, or to lower parasite intake from the chicory pasture, due to the different plant structure between chicory and grass/clover swards.

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The performance of broiler chicks fed cottonseed meal supplemented with lysine and or ferrous sulphate

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Introduction Cottonseed Meal (CSM) is a byproduct of the process used to extract oil from cotton seeds and contains 28- 35% crude protein in the Iran, depending on the amount of hull separation prior to the oil extraction process. Although CSM is high in protein, due to its low lysine levels and presence of toxic substance, gossypol, its utilization in poultry feed as a protein supplement is limited. Problems related to lysine and nutrient density are easily rectified by addition of synthetic lysine to poultry diets. However, solutions to the problems related to gossypol in CSM have been elusive. Gossypol, a naturally occurring anti-nutritional factor that is reduced broiler performance and increased their mortality (Smith, 1970). However, it has been shown that several factors, such as age, strain of chicks, dietary iron, and dietary lysine may affect birds' tolerance to gossypol (Clawson and Smith, 1966; Martin, 1990). The objective of this research was to evaluate the response of broiler performance when high levels of CSM were offered with Lysine (Lys), Ferrous sulphate (FS), and both in diet.

Materials and methods Five hundred day old chicks from Ross stock were used in a completely randomized design (CRD) with 5 treatments, with 4 replicates in each treatment. Treatments were: 0 CSM (Control, C), 25% CSM (CSM), 25% CSM supplemented with Lys (CSM+LYS), 25% CSM supplemented with ferrous sulphate (CSM+FS), 25% CSM supplemented with Lys and FS (CSM+LYS+FS). Lysine was added in 2% of CSM's protein and ferrous sulphate was added in 0.05% to the diets. Isocaloric and isoenergetic diets were formulated based on NRC 1994. Chicks were raised in normal condition until 14 days of ages and then randomly assigned to one of treatments until 49 days of ages. Feed refusals were collected and weighted daily and the average daily individual feed intake determined for each week. Live weight was recorded weekly. At the end of study (49 days old) one male broiler from each replication with minimal weight difference from mean of that replication, was slaughtered and carcass parameters and its hematocrit were assayed. Data were analysed by analysis of variance using GLM procedure of SAS® (2001).

Results Mean daily gain, feed conversion ratio, Carcass weight and hematocrit for different treatments are presented in the Table 1. As indicated in the table, results from the comparison of daily gain indicated that supplementing CSM with LYS significantly improved daily gain in the experimental periods. Also supplementing CSM with LYS significantly improved FCR in the experimental periods. However addition of ferrous sulphate to the diets containing CSM had not beneficial effects on the FCR compare to the control group. Significantly higher ($P<0.05$) carcass weight was observed to those chicken fed lysine and lysine+ ferrous sulphate diets compared to those fed the ferrous sulphate. The diets did not affected on the hematocrit of chickens. However, results indicated that supplementing diets with LYS and FS had better effects on the broiler performance.

Table 1 Effect of different treatments on broiler performance and their hematocrit.

Item	Treatments					SEM
	Control	CSM	CSM+FS	CSM+Lys	CSM+FS+Lys	
Daily gain (g)	73.37 ^{a}	56.56 ^{b}	58.95 ^{b}	66.28 ^{ab}	71.72 ^{a}	1.663
FCR	1.72 ^{a}	2.03 ^{c}	1.97 ^{bc}	1.85 ^{ab}	1.79 ^{a}	0.026
Carcass weight (kg)	1.96 ^{a}	1.31 ^{b}	1.37 ^{b}	1.81 ^{a}	1.80 ^{a}	0.071
PCV (%)	33.75 ^{a}	33.50 ^{a}	37.00 ^{a}	36.75 ^{a}	38.25 ^{a}	0941

* Means with unlike superscripts are different ($P\leq0.05$)

Conclusions In general the quality of cottonseed meal is affected by the method of its oil extraction. Nevertheless its nutritional value, due to incorrect hull separation procedure, is usually lower than those reported by NRC. However, in some part of Iran, due to the mechanical extraction of the oil, the amount of its free gossypol in the CSM is low and contained gossypol-lysine complex. With considering these facts, results of this study indicated that supplementing diets with Lysine to the CSM diets in broiler diets improved its nutritional value. The effect of Ferrous sulphate was not significant probably due to the low amount of free gossypol in CSM in this experiment. The results of this study suggest that with an adequate lysine supplementation, soybean meal can be replaced with cottonseed meal in growing broiler diets without any adverse effects on their performance.

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Effect of rapeseed variety on the chemical composition and predicted amino acid availability for poultry of rapeseed meal

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Introduction One of the richest sources of commercially available home grow protein is rapeseed meal (RSM), but its inclusion in livestock diets is approximately half that of soyabean meal (SBM, DEFRA statistics). Compared with SBM, both protein content and quality in RSM is inferior, but it is possible that particular varieties of rapeseed, together with an appropriate protocol for the extraction and subsequent treatment of rapeseed meal, may reduce the difference in the nutritive value of RSM and SBM. This would make the inclusion of larger amounts of RSM in livestock diets more attractive. The objective of this experiment was to determine how great the variation in the chemical composition and predicted amino acid availability for poultry of RSM was when prepared from modern UK varieties of rapeseed.

Materials and methods A total of 15 samples of rapeseed comprising five varieties (Canberra, Fortress, Gemini, Royal and Winner) from three sites (Hampshire, Cambridgeshire and Northumberland) were collected. These samples were crushed and extracted with petroleum ether on a laboratory scale to produce samples of rapeseed meal. The samples of RSM were then analysed for dry matter (DM), organic matter (OM), crude protein (CP), neutral detergent fibre (NDF) and water soluble carbohydrates (WSC). The concentration of available essential amino acids for poultry was predicted by near infrared reflectance spectroscopy. The effect of variety and location grown on chemical composition and predicted amino acid availability was estimated by analysis of variance.

Results There were no significant differences between varieties in the chemical composition of rapeseed meal (Table 1). However, there were differences in the concentrations of available essential amino acids (Table 2) with Canberra supplying more available methionine, tryptophan, valine, leucine, phenylalanine and histidine than Royal. The location where grown had a significant ($P<0.05$) effect on DM content and on the concentrations of many available amino acids including lysine, valine, threonine and histidine.

Table 1. *The chemical composition of different varieties of UK rapeseed meal*

	Variety					SEM	Sig.
	Canberra	Fortress	Gemini	Royal	Winner		
DM (g/kg fresh)	920	919	921	921	915	2.1	ns
Chemical composition (g/kg DM)							
OM	947	947	942	946	947	1.4	ns
CP	346	327	342	323	325	14.5	ns
NDF	479	500	497	486	486	11.2	ns
WSC	71.4	78.2	82.7	82.6	82.5	5.5	ns

Table 2. *Predicted concentration of available essential amino acids (g/kg DM) in UK varieties of rapeseed meal*

Amino	Variety					SEM	Sig.
acid	Canberra	Fortress	Gemini	Royal	Winner		
Lysine	13.3	13.4	13.5	12.0	12.3	0.42	ns
Methionine	5.7	5.2	5.4	4.8	5.1	0.10	**
Cysteine	4.6	4.8	5.3	4.6	4.4	0.29	ns
Threonine	9.9	9.9	10.1	9.2	9.4	0.21	ns
Tryptophan	3.2	3.1	3.2	2.8	2.9	0.08	*
Valine	12.7	12.1	12.2	11.0	11.6	0.17	**
Isoleucine	9.5	9.7	9.4	8.4	8.8	0.25	ns
Leucine	17.9	18.1	17.4	16.0	16.8	0.35	*
Phenylalanine	11.1	10.5	10.0	8.8	9.7	0.21	**
Histidine	7.7	7.3	7.1	6.5	6.9	0.16	**

* $P<0.05$; ** $P<0.01$

Conclusion Chemical composition alone does not reveal differences in the nutritive value of the varieties studied. Although the differences are relatively small, the protein quality of rapeseed meal is affected by the variety of rapeseed used, with the conventional variety of Canberra having a higher predicted protein quality for poultry than the hybrid Royal. The selection of rapeseed varieties with a relatively high protein content and quality might help to increase the utilisation of RSM in livestock diets provided any other constraints could be overcome.

Acknowledgements Funding for this work by the UK Department for the Environment, Food and Rural Affairs (DEFRA) and by the Home Grown Cereals Authority is gratefully acknowledged.

Effect of dietary Quillaja saponins and Curcumin on the performance and immune status of weaned piglets

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Introduction Quillaja saponins are known to have immunomodulatory properties and are commonly used as vaccine adjuvants to promote immune response. Curcumin is an extract of the spice turmeric and has also been suggested to have immunomodulatory activity. Commercial weaning occurs before the piglet active immune system is developed and this alongside the withdrawal of sow milk antibodies, results in immuno-incompetence during the initial post-weaning period (Krakowski *et al*., 1998). The hypothesis that dietary Quillaja saponin or Curcumin will enhance piglet immune status, health and performance during the first 20 days post weaning was therefore tested.

Materials and methods A total of 192 weaned piglets (62.5% Large White, 25% Landrace and 12.5% Duroc), aged 28.8 ±0.05 days, were allocated to 4 treatments, balancing for litter, weight and sex, in a 2 x 2 factorial design. Factors were with or without dietary Quillaja saponin (750 mg/kg during week 1, 300 mg/kg weeks 2-3) versus with or without dietary Curcumin (200 mg/kg). Diets contained no antibiotic and were formulated to contain 16.8 MJ DE/kg and 17 g lysine /kg between d 0-7, 15.5 MJ DE/kg and 15.5 g lys /kg from d 8-20. Pigs were housed in slatted flat deck pens, with 8 pigs per pen, 6 pens per treatment. Pigs were weighed on d 7, 14 and 20 post-weaning. Diets were fed ad-libitum and pen feed intake recorded daily. On each of d 6 and d 20 post weaning, 8 pigs per treatment (littermates representative of pen performance) were slaughtered. Blood sampled from the peripheral circulation was analysed for IgA and IgG using an ELISA. Data were analysed as a 2 x 2 factorial design in Minitab 12.2 using the General Linear Model procedure. Wean weight and age were included in the model as covariates in performance data analyses.

Results Dietary treatment had no effect on piglet growth (ADG) during the post-weaning period (Table 1). Feed intake (ADFI) and feed conversion ratio (FCR) were similar between treatments during the first 2 weeks post-weaning. However between d 15-20, Quillaja supplemented pigs had higher ADFI and FCR. This resulted in higher overall ADFI and FCR between d 0-20 post weaning. Serum immunoglobulins (Ig) were not affected by diet on d 6 post-weaning. However serum IgG levels in Q treated pigs were 54% higher than controls on d 20 (P<0.05), Table 2. Curcumin had no effect on serum Ig levels. There were no interactions between effects of Curcumin and Quillaja.

Table 1 *Main effects of dietary treatment on piglet average daily gain (ADG) g/pig/day, piglet average daily feed intake (ADFI) g/pig/day, and piglet feed conversion ratio (FCR), during the first 20 days post weaning*.

	QUILLAJA				CURCUMIN			
	Without	With	sem	Sig	Without	With	sem	Sig
Wean wt	7.66	7.63	0.08	ns	7.65	7.64	0.08	ns
ADG 0-20	347	352	10.0	ns	348	352	10.0	ns
ADFI 15-20	572	621	16.5	P<0.05	596	597	16.5	ns
ADFI 0-20	388	420	12.0	P<0.1	397	411	12.0	ns
FCR 15-20	1.20	1.35	0.04	P<0.05	1.26	1.29	0.04	ns
FCR 0-20	1.12	1.20	0.02	P<0.05	1.14	1.18	0.02	ns

Table 2 *Effect of dietary treatment on serum IgG and IgA concentrations (mg/ml) on days 6 and 20 post-weaning.*

		QUILLAJA				CURCUMIN			
		Without	With	sem	Sig	Without	With	sem	Sig
IgA	D6	0.139	0.163	0.021	ns	0.160	0.143	0.022	ns
	D20	0.212	0.266	0.022	ns	0.240	0.239	0.022	ns
IgG	D6	11.33	11.28	1.67	ns	12.51	10.10	1.67	ns
	D20	11.39	17.51	1.95	P<0.05	13.98	14.92	1.95	ns

Discussion The increase in serum IgG in Q treated pigs on d 20 post-weaning may be linked to the increase in FCR between d 15-20. It is likely that the increased FCR is a result nutrient partitioning away from growth towards eliciting this immune response (Klasing and Barnes, 1988). This is despite the improved ADFI seen during this period. This effect supports our hypothesis that Quillaja saponins would modulate immune status. In conclusion, dietary Quillaja saponins may have the potential to manipulate immune response but not growth in weaned piglets.

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Repeated exposure to vasectomised rams during the beginning of the breeding season improves the synchrony of oestrus and lambing in ewes

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Introduction

Introduction of a ram to anoestrous ewes induces an almost instantaneous rise in LH pulse frequency. This is commonly sufficient to overcome the seasonal suppression of the hypothalamic-pituitary axis and induce a synchronous first ovulation (Martin *et al.,* 1986). A preliminary study at the University of Newcastle upon Tyne identified a significant positive effect of repeated fence-line ram exposure on the synchrony of breeding and lambing in ewes (Hawken *et al.,* 2003). The ram effect is widely accepted to be predominantly mediated through pheromones however previous studies have emphasised the importance of other exteroreceptive cues. Optimal response to the ram effect during anoestrus is obtained when ewes are exposed to the full complement of male sensory signals (Pearce and Oldham, 1988). This study investigated the application of repeated exposure to vasectomised rams during the beginning of the breeding season as a non-pharmacological method of synchronisation of oestrus and lambing in ewes.

Materials and methods

During September 2002, multiparous mule ewes were assigned to groups C (n=106) or R (n=105). Vasectomised rams (n=3) were introduced to Group R on Days 0 (September 10th), 17 and 34 of the experiment for a period of 24 hrs on each occasion. Group C were isolated from any ram contact for the duration of the experimental procedure. Ewes in groups C and R were mixed and raddled rams (n=10) were introduced for breeding on Day 50. Raddle marks were recorded daily to identify the timing and numbers of ewes mated during the first oestrous cycle and then recorded weekly for the two subsequent oestrous cycles.

Results

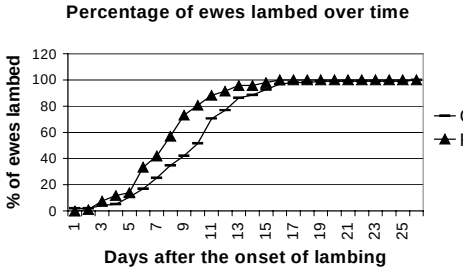
Time of breeding after ram introduction (RI) and conception rates to first service

Ram-exposed ewes were, on average, mated earlier than control ewes. At each daily observation the cumulative number of R ewes marked was consistently greater than control ewes being significantly different on Day 1 (11% vs 20%; P<0.01) and from Days 4 through to Day 10 post RI (at least P<0.05). The variance around the median time from RI to marking was less for R than C ewes (Levene's test; P<0.01) indicating greater synchrony in the timing of first service within ram-exposed ewes. There was no significant difference in the number of ewes conceiving to first service.

Lambing data

Within those ewes lambing to first service, ram-exposed ewes had an earlier mean lambing date than control ewes (P<0.001). By day 8 of the lambing period, 73% of ram exposed ewes had lambed compared to only 34% of control ewes (P<0.001) and this disparity between groups was sustained (at least P<0.05) until Day 17 of the lambing period. The variance around the median time from RI to lambing was less for R than C ewes (Levene's test; P<0.01) indicating greater synchrony of lambing within ram-exposed ewes. There was no significant difference between groups in the total number of lambs born per ewe (2.16 ± 0.07 vs 2.00 ± 0.07 for C and R ewes respectively).

Breeding data			**Lambing Data**
Group	Mean time from RI to breeding (days ± SE)	Ewes conceiving to 1st service	*Mean time from RI to lambing (days* ± SE*)*
R (n=106)	4.44 ± 0.26	99/106 (93%)	151.0 ± 0.34
C (n=104)	6.25 ± 0.374	95/104 (91%)	153.1 ± 0.40
P value	P<0.001	P=0.436	P=0.001



Conclusion

In conclusion periodic, repeated exposure of ewes to vasectomised rams during the breeding season advanced the timing and improved the synchrony of oestrus and breeding. The shortening of the service period resulted in a significant compaction of the lambing period within the ram exposed ewes. This is evident in that all ram exposed ewes that conceived during their first service period subsequently lambed within 15 days of the onset of lambing, with no negative effect on ewe fertility.

Acknowledgement

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The use of urinary and recombinant human FSH preparations to induce superovulation in sheep and the effect on FSH and LH concentrations

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Introduction Most ovarian stimulation protocols in ruminants utilise pituitary extracts that contain FSH with varying amounts of LH contamination. Protocols utilising these extracts in sheep generally give superovulation responses that are highly variable in the range of 0-15 ovulations. The use of pure recombinant human FSH (rhFSH) is widespread in clinical medicine. The aims of the study are: a) to determine if rhFSH will induce superovulation in sheep and whether this differs in response to human menopausal gonadotrophin (HMG), which is more similar to pituitary extracts with an equal amount of LH to the FSH; b) to monitor the effect of the human FSH's on the endogenous LH and FSH concentrations.

Materials and methods Twelve mule ewes had oestrous cycles synchronised with progestagen sponges (day 0, pm) and an injection of cloprostenol at the time of sponge withdrawl (day 4, am). Ewes were randomally allocated to two groups, rhFSH (Gonal-F, Serono) and HMG (Menogon, Ferring Pharmaceuticals), both groups received 150 iu of FSH twice a day from day 0 (pm) until day 5 (am) as i.m. injections in 1ml of saline carrier. Daily jugular blood samples were taken and follicle development was assessed using transrectal ultrasonography from day 0 until day 5 (pm). Buserelin (8µg i.m.) was administered on day 5 (pm) to induce ovulation. Ovulation rates assessed by laproscopy and a final blood sample taken on day 8 (am). Hormone concentrations (oFSH, hFSH, oLH) were determined by previously validated double antibody RIA. After appropriate data transformation SPSS was used for statistical analysis.

Results There was a marked superovulation in all ewes (Figure 1). The range of numbers of ovulations per sheep were similar for the two groups (rhFSH, 9-27 and HMG, 11-31). The percentages of 4-9mm follicles ovulating were 74 ±4.9 (60-85) and 72 ±5.9 (48-90), whilst ovarian cysts were present at a low rate 1.3 ±0.61, (0-3) and 1.2 ±0.65, (0-4) for rhFSH and HMG respectively. Total numbers of follicles increased with time ($P<0.001$). The numbers of small follicles (~3mm) after an initial increase on day1 decreased ($P<0.01$), medium follicles (4-6mm) increased from day 0 to 5 ($P<0.001$) and large follicles (7-9 mm) increased after day 1 ($P<0.001$). However, with all follicle parameters there were no significant effects of or interactions with treatment.

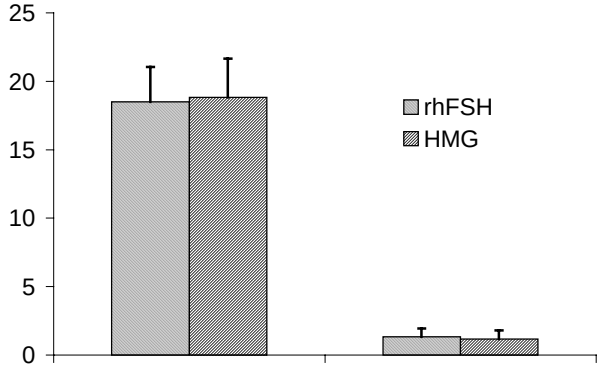

Figure 1 Ovulations and cysts at laproscopy (mean and s.e.)

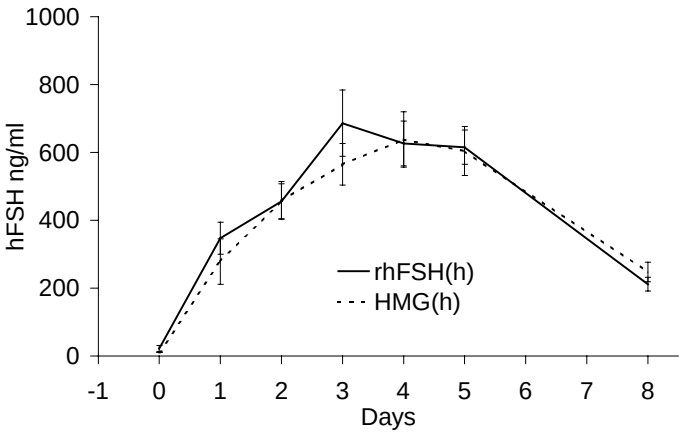

Figure 2 hFSH concentrations (mean and s.e.)

There were no differences between the two types of FSH in terms of oFSH, oLH or hFSH. Both the oFSH and oLH declined for both groups with time while the sheep received the FSH doses and recovered to previous levels subsequently. The oLH did not significantly differ between the treatments despite the HMG treatment containing equal amounts of LH (human). The hFSH profile is shown in figure 2 and shows the hFSH concentrations to increase during treatment and subsequently decline as the hFSH is metabolised by the sheep. These results indicate that although there was biological cross-reactivity, there was little immunological cross-reactivity within the RIAs.

Conclusions Both rhFSH and HMG are effective in inducing superovulation in sheep with a similar ovarian response obtained for the rhFSH to the HMG which contains equal amounts of LH and FSH. These responses were greater and more consistent than similar doses using ovine pituitary extract FSH. Unlike the response to the ovine pituitary extract FSH all of the sheep in this study responded to the FSH used. Both FSH preparations increased hFSH but marginally lowered the endogenous FSH and LH. These results suggest that human FSH preparations can be used as part of ovine superovulation protocols, although more work is required to assess the impact of the human FSH forms on oocyte quality.

Effect of low progesterone concentration during oestrus synchronisation on subsequent ovulation and postovulatory endocrine function in dairy cows

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Introduction In addition to work showing a detrimental effect of low postovulatory progesterone on embryo development (Mann and Lamming, 2001), a number of studies have demonstrated reduced fertility in animals in which plasma progesterone concentrations were low during the cycle preceding insemination (Holness et al., 1981; Folman et al., 1990). In this study we investigated the effect of reduced progesterone concentrations during oestrus synchronisation on the timing of ovulation and on progesterone concentrations during the ensuing cycle.

Materials and methods The study was performed in 20 non-lactating multiparous Holstein Friesian cows following procedures approved by the local ethics committee. Cows were housed in individual loose boxes and fed hay and water *ad libitum* plus a 4kg concentrate supplement. Oestrous cycles were synchronized by insertion of either a normal strength CIDR (InterAG, New Zealand) (High P; n=10) or a used CIDR (Low P; n=10) for 11 days at which point the CIDR was removed and a single im injection of prostaglandin (2ml Estrumate, Schering-Plough, Welwyn Garden City, UK) administered. From day of CIDR insertion until 28 days after CIDR removal daily plasma samples were collected by jugular venepuncture and immediately spun and plasma collected and frozen at -20°C until assayed for progesterone (P4) and oestradiol (E2). Ovulatory follicle development was monitored daily from the day of CIDR removal until ovulation was detected by trans rectal ultrasonography using a real-time B mode ultrasound scanner (Concept 2000, Dynamic Imaging, Livingstone, UK) fitted with a 7.5 mHz linear array transducer. Characteristics of preovulatory follicle development and time of ovulation and postovulatory P4 rise between treatment groups were analysed by Students t test. Differences in postovulatory progesterone secretory pattern were analysed by repeated sample analysis of variance.

Results During the synchronization period the mean plasma P4 concentration was lower ($P<0.001$) in the Low P group than in the High P group (Table 1). In the High P group progesterone concentrations remained relatively constant during the synchronisation period while in the Low P group concentrations showed a marked ($P<0.001$) decline over this period. Despite the relatively low progesterone levels in the Low P group, progesterone showed a further decline at CIDR removal and throughout this period no animals showed oestrus and no evidence of premature ovulation was detected during scanning. Following CIDR removal the interval to ovulation was shorter ($P<0.001$) in the Low P group. This shorter period to ovulation was accompanied by elevated ($P<0.001$) preovulatory oestradiol concentrations and the ovulation of a larger ($P<0.05$) ovulatory follicle. However, despite marked differences in preovulatory events, during the subsequent luteal phase there was no significant difference between the High P and Low P groups in time to post ovulatory progesterone rise, plasma concentrations of progesterone during the ensuing luteal phase or time from ovulation to subsequent luteolysis. Furthermore, plasma concentrations of oestradiol during the ensuing luteal phase were also similar between groups.

Table 1. Reproductive characteristics in cows following high or low P4 concentration during cycle synchronisation

	High P (n=10)	Low P (n=10)	Significance
Mean P4 during synchronisation	2.0±0.4 ng/ml	5.8±0.7 ng/ml	P<0.001
Mean E2 during synchronisation	1.2±0.1 pg/ml	2.9±0.3 pg/ml	P<0.001
Interval to ovulation	6.0±0.4 days	4.1±0.1 days	P<0.001
Preovulatory oestradiol	3.0±0.3 pg/ml	5.4±0.5 pg/ml	P<0.001
Size of follicle at ovulation	13.6±0.6 mm	15.8±0.7 mm	P<0.05
Time to postovulatory P4 rise	2.5±0.2 days	3.0±0.3 days	ns
Mean luteal phase P4	4.8±0.3 ng/ml	4.4±0.3 ng/ml	ns
Time to subsequent luteolysis	18.5±0.7 days	19.2±0.5 days	ns

Conclusions The presence of low progesterone concentrations during an oestrous cycle synchronisation period resulted in the earlier ovulation of a larger follicle. However, this was not followed by any altereration in luteal function during the ensuing cycle. This suggests that any impairment in fertility following a period of low progesterone may result from impaired follicle/oocyte quality rather than from any deficiency in postovulatory progesterone secretion during the subsequent cycle.

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Energy substrates in bovine oviduct fluid and blood plasma

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Introduction Reproductive wastage in cattle is largely the result of fertilisation failure and early embryo loss (Sreenan *et al*., 2001). Oviduct fluid forms the environment in which the oocyte and spermatozoa undergo final changes before fertilization and the early embryo develops. However, while oviduct fluid is partly a transudate of blood plasma little is known of its biochemical composition and especially the concentration of energy substrates essential for early embryo development. The objective of this study was to measure the comparative concentrations of glucose, lactate and pyruvate in cattle oviduct fluid and blood plasma on different days of the oestrous cycle.

Materials and methods Reproductively normal crossbred heifers (n=30) of similar age (average 20 ± 4 months), live weight (408 ± 6.3 kg) and body condition score (3.2 ± 0.1 units) were used for oviduct fluid collection. The day of standing oestrus was designated as day 0 and the energy substrates were measured on days 0, 2, 4 and 6 with each heifer used on one day only. Oviduct fluid was collected during a midventral laparatomy carried out under licence and in accordance with the EC Directive 86-609-EC. Following exteriorisation of the reproductive tract, catheters were inserted through the tubal ostium of the ipsilateral and contralateral oviducts to a distance of approximately 4cm and kept in place with two ligatures. The reproductive tract was then returned to the peritoneal cavity with the distal ends of each catheter remaining exteriorised and containing a sterile filter. Glucose, lactate and pyruvate were measured using an autoanalyser (Cobas Mira, Roche Instruments, UK). Glucose was measured by the glucose oxidase-peroxidase test combination, a commercially available kit (Glucose GOD – Perid, Boehringer Mannheim, ref no. 124036). Lactate was analysed by monitoring the formation of NADH from NAD+, catalysed by the enzyme lactate dehydrogenase in the presence of hydrazine sulphate. Pyruvate was measured by monitoring the oxidation of the reduced pyridine nucleotide NADH to NAD^+ by lactate dehydrogenase. Data were analysed by analysis of variance (PROC GLM, SAS v8.02, Cary, NC) with heifer-within-day as a random effect, day and side as fixed effects and day by side interaction. The main effect of day was tested using the heifer-within-day mean square. Significant differences were compared using the Tukey-Kramer option within SAS. A probability value of $P<0.05$ was considered significant. Values are presented as least square means ± SEM.

Results The results are shown in Table 1. There was no difference in the concentrations of glucose, lactate or pyruvate between ipsilateral and contralateral oviducts on any day and these data were pooled for subsequent analysis. Oviduct glucose concentrations did not differ between days but were lower than plasma concentrations on all days. Oviduct lactate concentrations were not different between days but were higher than plasma concentrations on all days. Oviduct pyruvate concentrations did not differ between days but were lower than plasma concentrations on days 0 and 2; however they did not differ from plasma concentrations on days 4 and 6.

Table 1. Energy substrate concentrations (means±sem) in oviduct fluid and blood plasma of heifers on specific days of the oestrous cycle

Day of cycle	Glucose (mM)		Lactate (mM)		Pyruvate (mM)	
	Oviduct	Plasma	Oviduct	Plasma	Oviduct	Plasma
0 (n=7)	3.17 ± 0.638^{a}	7.11 ± 1.071^{b}	5.35 ± 0.888^{a}	1.18 ± 0.188^{b}	0.11 ± 0.011^{a}	$0.15 \pm 0.015^{b,c}$
2 (n=8)	1.87 ± 0.624^{a}	6.11 ± 1.002^{b}	6.18 ± 0.869^{a}	0.71 ± 0.176^{b}	0.09 ± 0.011^{a}	$0.13 \pm 0.014^{b,c}$
4 (n=8)	2.74 ± 0.654^{a}	7.70 ± 1.002^{b}	6.26 ± 0.942^{a}	0.68 ± 0.176^{b}	0.12 ± 0.011^{a}	$0.12 \pm 0.014^{a,c}$
6 (n=7)	2.58 ± 0.744^{a}	6.09 ± 1.072^{b}	6.66 ± 1.037^{a}	0.78 ± 0.188^{b}	0.10 ± 0.013^{a}	$0.12 \pm 0.015^{a,c}$

Within substrates, values with different superscripts are significantly different (P<0.05).

Conclusions The concentrations of the energy substrates glucose, lactate and pyruvate in oviduct fluid do not vary during the postovulatory and early luteal phase of the oestrous cycle. Oviduct glucose concentrations are, however, lower and lactate concentrations higher than plasma concentrations over the same period, while oviduct pyruvate concentrations are lower than plasma concentrations on day 0 and 2 but similar on day 4 and 6. Information on these energy substrate concentrations is important not only in the study of early embryo loss but also in the search for an optimum culture medium formulation for the culture of in vitro produced cattle embryos.

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An examination of reproductive performance in Northern Ireland dairy herds

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Introduction Poor reproductive performance is a major problem on dairy farms throughout the United Kingdom and has been identified as the single most important problem in two recent farm surveys in Northern Ireland (AgriSearch, personal communication). The decline in reproductive performance is often attributed to increased genetic merit for milk production, but is also influenced by a large number of factors including changes in management practices and nutritional factors. The aim of this study was to examine reproductive performance in a range of dairy herds in Northern Ireland to identify the key factors influencing reproductive performance at farm level. This paper presents the findings of three years of study.

Materials and methods Nineteen dairy herds from across Northern Ireland, representing approximately 2500 Holstein-Friesian cows, were monitored for three successive years. Herds were selected as representative of those present throughout the region with a wide range of herd size, season of calving, concentrate input, genetic merit and level of milk production (Mayne *et al.*, 2002). All fertility data were recorded including details of calvings, heats and services. Each cow record terminated with either a subsequent calving or removal from the herd. The factors affecting herd reproductive performance, *viz.* heat detection rate (HDR), interval to first service (IFS) and conception rate to first service (CR), were examined. HDR was calculated using inter-heat intervals while CR was the number of cows calved over the total number of services in all cows (methods described by Mayne *et al, 2002*). Herd reproductive performance was compared using calving interval (CI), but variable removal rates between herds pre-empted adoption of alternative measures of assessment, re-appearance rate and in-calf rate. Re-appearance rates were defined as the proportion of cows which had a calving interval of ≤365 days (RR-365) or ≤400 days (RR-400), while in-calf rate (ICR-100) was defined as the proportion of cows intended for re-breeding that were in-calf again within 100 days of calving (Morton, 2001). Intention to rebreed was defined retrospectively as cows with ≥1 service or culled for infertility.

Results
A total of 7747 calvings were recorded across the 19 herds in the three years of study. Reproductive performance varied widely between herds (Table 1). Infertility was the primary reason for the removal of cows (26.5% of all removals) followed by locomotion (14.6%) and teat/udder problems (10.2%).

Table 1 Range in fertility performance across the 19 herds for three successive years

	Mean	SEM	Herd Range (Min-Max)	Average of Top 5 Herds
Interval to first service (days)	86.1	0.50	67 – 119	73
Heat detection rate (%)	71.9	0.52	55 – 89	82
Conception rate to first A.I (%)	40.3	0.67	18 – 61	55
Calving interval (days)	405.9	0.96	371 – 447	380
Removal rate (%)	26.2	0.50	19 – 39	21
Re-appearance rate (%):				
365-day	24.0	0.49	4 – 45	35
400-day	44.5	0.57	22 – 65	60
100-day in-calf rate (%)	46.0	0.61	16 – 71	65

Conclusions
Reproductive performance was generally poor, but varied greatly between herds. The best performance occurred in seasonal-calving herds where interval to first service was shortest and heat detection rates highest. Of cows that calved, only 24% re-calved within 365 days, representing considerable reproductive loss. The 400-day re-appearance rate offers more flexibility and is recommended to farmers in Northern Ireland as a more accurate assessment of reproductive performance than calving interval. In-calf rate is recommended as a short-term measure of assessing fertility.

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Investigating the biological interpretation of *adilopan* (appetite satisfaction), a term used by Nepalese hill farmers to evaluate fodder quality

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Introduction Livestock play an important role in sustaining rural livelihoods in the mid-hills of Nepal. Farmers in this region have an indigenous knowledge system for describing the nutritive value of tree fodders (Thapa et al., 1997) that they use in the management of fodder resources to cope with feed scarcity during the winter. Previous studies of farmers' knowledge revealed two descriptors for fodder: *posilopan*, meaning literally nutritiousness and related to protein supply, and, *obhanopan* literally meaning 'dryness and warmness', as opposed to 'chiso' which means 'wet and cold' but relating to how voraciously fodders are consumed and their overall dry matter digestibility (Thorne et al., 1999). These descriptors are widely and consistently used by Nepalese farmers (Walker *et al.*, 1999). Further investigation has led to the discovery of a third descriptor, '*adilopan*', (literal meaning 'duration of appetite satisfaction' used in association with the term '*obhanopan*'. This study investigates the biological interpretation of the term *adilopan*, revealing the importance to farmers of the extent to which tree fodders satisfy animal appetite.

Materials and methods Feeding trials were conducted on sixteen cattle, eight buffalo and 16 goats with average live weights (kg) of 149.9 (±23.13), 185.6 (±24.4 and 23.5 (± 3.34) respectively. The study lasted for two days during the winter season using six common fodder tree species, namely amliso (*Thysanolaena maxima),* dudhilo *(Ficus nerrifolia var nemoralis),* gogun *(Saururia nepalensis),* khasre khanyu *(F. semicordata* var *semicordata),* malbans *(Bamboosa nutans)* and nebharo *(Ficus auriculata)*. The time required to consume a fodder was measured as that between the onset of supply and their refusal of it. Duration of appetite satisfaction was then measured as the time between refusal and occurrence of behaviour indicative of hunger, such as salivation, mooing, tail wagging, heaving, head shaking and restlessness. Data were analysed using the general linear model including the effect of tree species and feeding period in the model.

Results There were differences amongst fodder species in the proportion of fresh mass offered that was eaten by cattle (p=0.000), buffalo (p= 0.045) and goats (p=0.000). In all animals, intake of more *chiso* types of fodder (dudhilo and nebharo) was higher than for *obhano* types (malbans, khasre khanyu and amliso). For cattle, there were differences (p=0.027) in the time taken to consume different tree fodders. The longest time was required for khasre khanyu (270 mins) and the shortest time (200 mins) for dudhilo and nebharo. There were also differences (p=0.000) between tree species in the time for which appetite of all animal types was satisfied. Malbans satisfied appetite of cattle for about 370 mins, whilst dudhilo for only 290 mins. Likewise, amliso satisfied appetite of buffalo for 380 mins whilst, nebharo and dudhilo for only about 320 minutes. Gogun satisfied appetite of goats for about 230 mins whilst, nebharo for 160 mins. In general more *obhano* tree fodders satisfied appetite of animals for longer than *chiso* fodders. *Obhano* fodders were also generally classified as *adilo*, although gogun that was locally categorized as a *chiso* fodder, satisfied appetite at a rate similar to *obhano* fodders.

Conclusions Farmers' perceptions about *adilopan* generally agreed with the present findings that *adilo* fodders, which were often also classified as *obhano*, satisfied appetite for longer than kamadilo tree fodders. However, the fact that gogun, was classified as a *chiso* tree fodder but satisfied appetite at a rate similar to *obhano* fodders, demsontrates a clear distinction between appetite satisfaction described using the *adilo* descriptor and consumption rate and dung quality referred to using the *obhan*o descriptor. This is an important distinction for targeting and communicating research aimed at helping farmers make efficient use of tree fodders during the dry season.

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The effect of two pure dairy breeds and their reciprocal crosses, and concentrate feeding management, on carcass characteristics and meat quality

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Introduction There is considerable interest in the use of alternative dairy breeds and cross breeding in the dairy industry as a method of improving herd fertility and longevity. Currently in Northern Ireland 47% of prime beef production is sourced from the dairy herd, and this proportion is likely to increase post implementation of the Mid Term Review of the Common Agricultural Policy. The present study was therefore undertaken to investigate the effects of two pure dairy breeds and their reciprocal crosses on carcass characteristics and meat quality.
Concentrate supplements for finishing beef cattle are normally offered either as coarse or pelleted rations. Currently in Northern Ireland the majority of beef farmers are part time and consequently feeding concentrates in one feed per day is a practical option on many units to reduce labour requirement. The effects of method of processing concentrate supplement and number of feeds per day on carcass characteristics and meat quality were also evaluated in this study.

Materials and methods The experiment involved a total of 42 steers, consisting of four genotypes, namely purebred Holstein (H), purebred Norwegian (N), H x N and N x H. All animals were offered grass silage *ad libitum* plus 4.5 kg concentrate supplemented with 100 g beef mineral and vitamin mixture, during the finishing period. The concentrate consisted of 540, 100, 230, 100 and 30 g/kg fresh weight of barley, maize, sugar beet pulp, soyabean and molasses. The concentrate was offered either as a coarse ration, which was offered either once (O) or twice (T) daily, or as a pelleted ration offered once daily (P). The steers were slaughtered at the end of the feeding study, which lasted 241 days. The *longissimus dorsi* (LD) muscle from the fore-rib joint was removed 48 h post-mortem and sarcomere length of the muscle was determined immediately. Two 50 mm thick slices of muscle were vacuum packed and allowed to age for either 7 or 21 days post-mortem, in a cold room at 2ºC. Ultimate pH, colour, Warner Bratzler shear force (WBSF) and cooking loss was determined 7 days post-mortem using the methods detailed by Moss *et al.* (1993). WBSF was repeated after 21 day ageing post-mortem. The study was analysed as a continuous randomised block experiment using Genstat REML variance components analysis.

Results The mean carcass weights were 267, 266, 268, 265 (sed 8.9) kg for H, H x N, N x H and N, respectively and 265, 270, 265 (sed 7.3) kg for the P, O and T treatments respectively. The corresponding fat classes (1 = lean and 5 = fat) were 3.03, 3.05, 3.01, 3.01 (sed 0.102) and 2.94, 3.01 and 3.12 (sed 0.08) respectively. Animal performance data have been presented by Keady *et al.* (2004). The effects of breed and concentrate feeding management on meat quality are presented in Table 1. Relative to the two pure breeds WBSF after 21 days ageing was lower in the reciprocal crosses, the decrease in the N x H cross being significant (P<0.05). Breed had no effect (P>0.05) on sarcomere length, colour assessments L*, a* or b*, or WBSF after 7 days ageing. Offering the concentrate as a coarse ration once per day increased lightness values (L*) of the LD. At 7 days post slaughter cooking loss was lowest in the twice daily treatment, however there were no other concentrate feeding effects (P>0.05) on meat quality (a*, b*, ultimate pH, sarcomere length, WBSF). At 21 days ageing post slaughter, twice feeding resulted in significantly higher WBSF.

Table 1 The effect of breed and concentrate feeding management on meat quality

	Breed (B)					Conc. management (CM)				Significance[1]	
	Hol	Hol x NRF	NRF x Hol	NRF	sed	Pellets	Loose		sed	B	CM
Number of feeds						Once	Once	Twice			
Colour											
L*	43.9	41.8	42.2	43.5	2.52	40.4[a]	46.2[b]	42.0[a]	2.06	NS	*
a*	17.6	18.5	17.2	17.6	2.55	19.1	16.2	17.9	2.08	NS	NS
b*	13.5	14.9	14.0	14.3	1.30	14.8	13.8	14.0	1.06	NS	NS
Sarcomere length (mm)	2.46	2.29	2.59	2.40	0.125	2.34	2.36	2.55	0.102	NS	NS
Ultimate pH	5.53[ac]	5.54[ac]	5.50[bc]	5.56[a]	0.025	5.53	5.53	5.53	0.020	*	NS
Cook loss (%)	28.3	27.6	27.3	26.8	1.363	28.1[a]	28.4[a]	25.9[b]	1.113	NS	**
7 day WBSF (kg/cm^2)	2.11	2.08	1.89	2.17	0.178	2.14	1.94	2.10	0.145	NS	NS
21 day WBSF (kg/cm^2)	2.10[a]	1.88[ac]	1.75[bc]	2.13[a]	0.142	1.89[a]	1.83[a]	2.17[b]	0.116	*	**

[1] NS = not significant; * = P< 0.05; ** =P <0.01

Conclusions It is concluded from this study, that beef from reciprocal crosses of the Holstein and Norwegian breeds was more tender as determined by a lower Warner Bratzler shear force after 21 days ageing than the pure breeds. Furthermore, feeding concentrate twice daily decreased cooking loss and increased toughness as assessed by Warner Bratzler shear force after 21 days ageing.

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The effects of the inclusion of maize and whole crop wheat silages in grass silage-based diets on the performance of beef cattle offered two levels of concentrate

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Introduction Recent developments in maize breeding and in agronomic practices, particularly the development of complete cover plastic mulch, have resulted in the possibility of consistently producing high yields of high starch maize silage in Northern Ireland. Recent studies (Keady *et al*., 2002, 2003) at this Institute have clearly illustrated that inclusion of maize silage, varying in maturity, consistently increases the performance of lactating dairy cows. Keady *et al*. (2002, 2003) concluded that the inclusion of maize silage in the diet of dairy cows had a potential concentrate sparing effect of up to 3 kg/cow/day. Currently there is considerable interest from beef producers of the potential effects of the inclusion of either maize or whole crop wheat (WCW) silages on the performance of beef cattle. The objective of the present study was to evaluate the effects of including maize and WCW silages in grass silage-based diets on food intake and animal performance of beef cattle offered two levels of concentrate.

Materials and methods Grass silages were offered either as the sole forage or in addition to either maize or WCW silages at a ratio of 40:60 alternative forage:grass silage and supplemented with either 3 or 5 kg concentrate/head/day. The six treatments were offered to 66 continental cross beef cattle (mean initial live weight 523 (sd 37.2 kg) in a continuous design, randomised block experiment. The maize silage was produced from the variety Crescendo which was grown under complete cover plastic mulch whilst the WCW was produced from the variety Claire. The grass silage was ensiled on 28 May from the primary growth of predominantly perennial ryegrass swards which were precision-chopped and treated with an inoculant at ensiling. The forages were offered *ad libitum* following mixing in a diet wagon once per day whilst the concentrate was offered in two equal feeds daily. The concentrate consisted of 500, 120, 200, 150 and 30 g/kg of barley, maize meal, sugar beet pulp, soya and molasses respectively. Each animal received 100 g mineral vitamin mixture per day with the concentrates. Total diet digestibility studies were undertaken using three cattle per treatment.

Results The forages were well preserved with pH and concentrations of dry matter (DM), ammonia nitrogen (N), crude protein and *in vivo* DM digestibility of 4.23, 4.11 and 4.24; 108, 93 and 151 g/kg N, 116, 80 and 97 g/kg DM; and 0.692, 0.580 and 0.704 respectively for the grass, maize and WCW silages respectively. The effects of forage type and concentrate feed level on animal performance are presented in Table 1. There were no forage type x concentrate feed level interactions (P>0.05), therefore the main effects are presented. Including alternative forages in the diet increased (P<0.01) forage and total DM intakes. Including WCW in the diet increased liveweight gain (P<0.05), final live weight (P<0.05) and decreased killout proportion (P<0.01) and did not alter (P>0.05) carcass gain or carcass weight relative to grass silage offered as the sole forage. Including maize silage increased liveweight gain (P<0.01), final live weight (P<0.01), carcass weight (P<0.05) and carcass gain (P<0.05) and did not alter (P>0.05) killout proportion.

Table 1 The effect of including maize and whole crop wheat (WCW) silage on animal performance

	Forage				Concentrate (kg/d)			Significance[1]	
	Grass silage	Grass plus maize	Grass plus WCW	Sem	3	5	Sem	Forage	Concentrate
Forage intake (kg DM/d)	5.1[a]	5.8[b]	5.8[b]	0.15	6.0[b]	5.1[a]	0.13	**	***
Total intake (kg/d)	8.4[a]	9.1[b]	9.1[b]	0.15	8.5[a]	9.3[b]	0.13	**	***
Final live weight (kg)	601[a]	621[b]	614[b]	4.3	608[a]	616[b]	3.5	*	NS
Liveweight gain (kg/d)	0.86[a]	1.07[b]	1.01[b]	0.042	0.93[a]	1.03[b]	0.034	*	NS
Kill out (g/kg)	543[b]	539[b]	528[a]	3.5	537	537	0.3	*	NS
Carcass gain (kg/d)	0.51[a]	0.60[b]	0.50[a]	0.031	0.52	0.56	0.026	*	NS
Carcass weight	326[c]	334[b]	325[a]	3.1	326	331	2.5	*	NS
Conformation[2]	2.75	2.82	2.77	0.072	2.79	2.77	0.059	NS	NS
Fat class[3]	3.25	3.77	3.52	0.161	3.35	3.68	0.132	NS	NS

[1] There were no significant (P>0.05) forage type x concentrate interactions
[2] EUROP scale: 5, 4, 3, 2, 1 respectively
[3] EU fat classification, where 5 = fat, 1 = lean

Conclusions It is concluded that including either maize or WCW silage in grass silage-based diets increased food intake. However the increased liveweight gain obtained with the inclusion of WCW was due to gut fill effects, as WCW inclusion decreased killout proportion and subsequently had no effect on carcass gain or carcass weight. In contrast, maize silage inclusion increased both liveweight and carcass gains and final live weight and carcass weights.

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Duodenal flow and biohydrogenation of C18 polyunsaturated fatty acids in beef steers fed high sugar grass, red clover or grass/red clover mix silages

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Introduction Forage lipids contain a high proportion of the polyunsaturated fatty acids (PUFA) C18:2*n-6* and C18:3*n-3*. However, microbial biohydrogenation in the rumen results in extensive loss of these beneficial fatty acids. This experiment investigated the duodenal flow of fatty acids in beef steers offered grass or red clover silage, the latter of which has been shown to reduce biohydrogenation of C18:3*n-3* (Lee *et al.* 2003a). In addition the effect of silage prepared from a ryegrass with high water soluble carbohydrate (WSC) content was investigated, as previous research (Lee *et al.* 2003b) has shown that increasing the availability of WSC lowered rumen pH and increased the proportion of propionate, relative to other volatile fatty acids, conditions which have been linked to reduced biohydrogenation (Jenkins, 1993).

Materials and methods Six Hereford x Friesian steers 163 (se 5.9) kg, prepared with rumen and duodenal cannulae were allocated at random to receive one of five silage diets *ad libitum;* high sugar grass (HG); control grass (CG); HG and red clover (50:50 DM basis; HGR); CG and red clover (50:50 DM basis, CGR) and red clover (R). The experiment was conducted as a 5 x 5 incomplete Latin square with an additional randomly repeated sequence. There were four experimental periods each lasting 24 days, with a 14 day adaptation period to the diets, followed by a 10 day measurement period. Digesta flow at the duodenum was estimated using a dual phase marker system with $Yb(CH_3COO)_3$ and Cr EDTA as particulate and liquid phase markers, respectively. On days 20 and 21 of each period duodenal digesta was collected every three hours over a 24 h period. Lipid extraction and GC analysis is described by Lee *et al.* (2004) which also reports flows of C18:1 and the main CLA isomers. Statistical analysis was undertaken using an unbalanced analysis of variance, blocking according to period (Genstat 5; Lawes Agricultural Trust, 1997).

Results The principle chemical components of the silages were; DM: 277, 258, 289, 276, 309; NDF: 551, 587, 459, 482, 397; TN: 24.5, 25.4, 29.4, 29.2, 32.3 and WSC: 90.5, 55.3, 66.5, 43.8, 29.2 for HG, CG, HGR, CGR and R respectively. Silage pH ranged from 4.06 to 4.14 with a predominantly lactate fermentation. The control grass silage (CG) had a significantly lower dry matter intake than the other four silage treatments, with a consequently lower duodenal flow. There was a net increase in fatty acid flow between mouth and duodenum on the two grass diets and a net reduction when red clover was incorporated into the diet. Since the FA composition of the silages was similar the differences in intake of C18:0, C18:2*n*-6 and C18:3*n*-3 were related to differences in DM intake. Duodenal flows of C18:0 were higher ($P < 0.01$) and flows of C18:2*n-6* and C18:3*n-3* lower ($P < 0.01$) with the grass silage compared with the red clover mixtures or pure red clover. Biohydrogenation of C18:3*n-3* was reduced ($P < 0.001$) with increasing proportions of red clover in the diet.

Table 1. Effect of forage type on intake and ruminal fatty acid metabolism.

	HG	CG	HGR	CGR	R	s.e.d	P
DM Intake (kg/d)	4.4^{b}	3.6^{a}	4.7^{b}	4.6^{b}	4.5^{b}	0.42	*
Fatty acid intake (g/day)							
C18:0 stearic	1.82^{b}	1.41^{a}	2.43^{c}	2.37^{c}	2.55^{c}	0.207	***
C18:2*n-6* linoleic	17.5^{ab}	15.5^{a}	21.6^{b}	21.6^{b}	21.2^{b}	2.05	***
C18:3*n-3* linolenic	57.9^{b}	41.5^{a}	58.1^{b}	55.2^{b}	50.1^{ab}	6.01	***
Total fatty acids	105.7^{b}	82.8^{a}	113.8^{b}	111.4^{b}	101.7^{b}	11.29	*
Fatty acid flow to duodenum (g/day)							
C18:0 stearic	61.1^{c}	41.1^{ab}	49.0^{bc}	45.2^{b}	36.7^{a}	6.28	**
C18:2*n-6* linoleic	1.94^{b}	1.28^{a}	2.34^{bc}	2.15^{bc}	2.62^{c}	0.317	**
C18:3*n-3* linolenic	3.57^{b}	2.34^{a}	5.90^{c}	5.29^{c}	7.68^{d}	0.661	***
Total fatty acids	126.4^{c}	85.9^{a}	106.6^{bc}	98.5^{ab}	83.7^{a}	13.98	**
Biohydrogenation (%)							
C18:2*n-6* linoleic	89	92	89	90	88	1.7	NS
C18:3*n-3* linolenic	94^{c}	95^{c}	90^{b}	90^{b}	85^{a}	1.5	***

Conclusion The decrease in duodenal flow of C18:0 and the increase in duodenal flow of C18:3*n-3* is associated with a reduction in C18:3*n-3* biohydrogenation when feeding red clover. The mechanism for this action is yet to be determined but may be due to intrinsic chemicals within red clover such as polyphenol oxidase and/or changes which occur in the microbial biohydrogenation pathways of C18 PUFA on red clover diets (Lee *et al.* 2004a).

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Duodenal flow of C18:1 and conjugated linoleic acid isomers in beef steers fed high sugar grass, red clover or grass/red clover mix silages

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Introduction Biohydrogenation of polyunsaturated fatty acids (PUFA) such as C18:2*n-6* and C18:3*n-3* results in the formation of C18:0 and numerous intermediary products such as the C18:1 *cis* and *trans* isomers and conjugated and non-conjugated C18:2 *cis* and *trans* isomers. Interest in these isomers has grown with the identification of biologically active isomers of conjugated linoleic acid (CLA *cis*9 *trans*11 and CLA *trans* 10 *cis*12) and enzymatic pathways for CLA *cis* 9 *trans*11 formation from C18:1 *trans*11, both in the mammary gland and muscle. This abstract reports on the duodenal flow of biohydrogenation intermediates, with the objective of explaining the reduced biohydrogenation with red clover silage (Lee *et al.* 2004).

Materials and methods The experimental design and statistical analysis were described by Lee *et al.* (2004). In short duodenal liquor was collected from six steers fed one of five silage diets (high sugar grass (HG); control grass (CG); HG and red clover (50:50 DM basis; HGR); CG and red clover (50:50 DM basis; CGR) and red clover (R)) conducted as a 5 × 5 incomplete Latin square with an additional repeated sequence. Digesta fatty acids were obtained by direct hydrolysis, with added internal standard (C21:0), in 5 M KOH in aqueous methanol. Fatty acids were bimethylated (Kramer and Zhou, 2001) and analysed by GC on a CP-Select CB for FAME column (100 m × 0.25 mm ID, Varian Inc.) with split injection (1:30). Peaks were identified from external standards and quantified using the internal standard.

Results The differences in flow between the two grass silages HG and CG may be accounted for in terms of DM intake (Lee *et al.* 2004), with the exception of CLA *trans*10 *cis*12 which was higher on the CG diet. The main isomers of C18:1 *trans,* C18:1 *cis* and CLA were *trans*11, *cis*9 and *trans*10 *cis*12, respectively. The proportional content of *trans*11, reduced with increasing red clover content of the diet; 0.78, 0.72 and 0.65 of total C18:1 *trans* for HG and CG, HGR and CGR and R, respectively. There was little change in the proportional composition of C18:1 *cis* with the exception of *cis* 12, which increased with red clover. Total CLA as a proportion of total FA flow increased with red clover, however the proportion of CLA *cis*9 *trans*11 declined and that of CLA *trans*10 *cis*12 increased significantly when red clover was incorporated into the diet or when fed separately.

Table 1. Duodenal flow in g/d of C18:1 and CLA isomers.

	HG	CG	HGR	CGR	R	s.e.d	P
C18:1 *trans* 6/7/8	0.501^{c}	0.275^{ab}	0.392^{bc}	0.287^{ab}	0.225^{a}	0.0784	**
C18:1 *trans* 9	0.251^{c}	0.145^{ab}	0.202^{bc}	0.156^{ab}	0.128^{a}	0.0382	**
C18:1 *trans* 10	0.362^{b}	0.237^{a}	0.323^{ab}	0.286^{ab}	0.241^{a}	0.0542	*
C18:1 *trans* 11	8.63^{b}	4.86^{a}	5.78^{ab}	4.68^{a}	3.26^{a}	1.441	*
C18:1 *trans* 12	0.529^{b}	0.297^{a}	0.490^{b}	0.409^{ab}	0.456^{b}	0.0676	**
C18:1 *trans* 13 + *cis* 6	0.797^{b}	0.463^{a}	0.744^{b}	0.723^{b}	0.675^{ab}	0.1407	*
Total C18:1 *trans*	11.07^{c}	6.27^{ab}	7.93^{bc}	6.55^{ab}	4.99^{a}	1.713	*
C18:1 *cis* 9	3.12^{b}	1.94^{a}	2.61^{ab}	2.19^{ab}	2.05^{a}	0.472	*
C18:1 *cis* 10	0.967^{b}	0.555^{a}	0.916^{b}	0.780^{b}	0.868^{b}	0.1098	*
C18:1 *cis* 11	0.418^{b}	0.261^{a}	0.351^{ab}	0.333^{ab}	0.275^{a}	0.0654	*
C18:1 *cis* 12	0.182^{b}	0.102^{a}	0.193^{b}	0.169^{ab}	0.221^{b}	0.0349	*
C18:1 *cis* 13	0.080^{b}	0.044^{a}	0.063^{ab}	0.056^{a}	0.048^{a}	0.0114	**
C18:1 *cis* 15	1.08	0.674	1.21	0.953	1.13	0.228	NS
Total C18:1 *cis*	5.86^{b}	3.58^{a}	5.34^{b}	4.48^{ab}	4.60^{ab}	0.828	*
CLA *cis* 9 *trans* 11	0.061^{b}	0.044^{ab}	0.043^{ab}	0.031^{a}	0.022^{a}	0.0147	*
CLA *trans* 10 *cis* 12	0.064^{a}	0.078^{a}	0.164^{b}	0.190^{b}	0.176^{b}	0.0466	*
CLA *cis* 9 *cis* 11	0.008	0.002	0.022	0.011	0.012	0.0119	NS
CLA *trans* 9 *trans* 11	0.065^{b}	0.046^{ab}	0.027^{a}	0.006^{a}	0.045^{ab}	0.024	*
Total CLA	0.198	0.170	0.257	0.239	0.260	0.0645	NS
Total fatty acids	126.4^{c}	85.9^{a}	106.6^{bc}	98.5^{ab}	83.7^{a}	13.98	**

Conclusion Increasing the content of red clover in the diet was accompanied by a shift in duodenal fatty acids towards increased levels of CLA *trans*10 *cis*12 and C18:1 *cis*12 and reduced levels of CLA *cis*9 *trans*11 and C18:1 *trans*11. These shifts in CLA and C18:1 isomer production are observed when increasing the concentrate content of a diet (Beaulieu *et al.* 2002) which also coincides with a reduction in biohydrogenation of C18:3*n-3* and C18:*2n-6* as a result of changes in the diversity of the rumen microbial population. These changes may explain the drop in biohydrogenation observed on the red clover diet in this study (Lee *et al.* 2004).

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The effect of gender and the plane of nutrition during the growing and finishing phases, on carcass characteristics and meat quality

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Introduction Growth rate of beef cattle is influenced by gender and can also be manipulated through changes in the plane of nutrition offered throughout the lifetime of the animal. Due to the low profitability of calf production at present it is essential to achieve optimum carcass weight as cheaply and efficiently as possible. Compensatory growth, whereby a restriction in growth during a period in life is compensated by higher growth rates later in life, may have the potential for achieving cost effective animal performance from beef cattle. The aim of the present study was to evaluate the effects of plane of nutrition during the first winter growth and final winter finishing phases on carcass characteristics and meat quality of steers and heifers. Furthermore the effects of *ad libitum* concentrate systems during the finishing phase were also evaluated.

Materials and methods The study involved a total of 144 spring-born continental cattle, 72 steers and 72 heifers, which were allocated to 18 treatments, commencing in the autumn of their first year. During the first winter growth phase animals were offered a diet (GPD) of grass silage *ad libitum*, supplemented with either, 0 (Low), 1.5 (Medium) or 3.8 (High) kg concentrates/head/day. Subsequently all animals received a common summer diet which consisted of grazed grass or grass silage supplemented with concentrates. During the final finishing period, cattle were offered a finishing phase diet (FPD) consisting of grass silage *ad libitum* supplemented with either 3 (Low) or 6 (Medium) kg concentrates/head/day or concentrate *ad libitum* (High) supplemented with 5 kg fresh silage daily. Concentrates offered during the first winter growth phase consisted of 500, 175, 200, 100 and 25 g/kg fresh weight of rolled barley, soyabean, molassed sugar beet pulp, maize meal and vitamins and minerals respectively, whilst the concentrate offered during the final winter finishing phase consisted of 545, 100, 230, 100 and 25 g/kg fresh weight of rolled barley, maize meal, sugar beet pulp, soyabean and molasses. During the final winter finishing phase all animals received 100 g/day of a mineral and vitamin mixture. Cattle were slaughtered in blocks at consistent intervals on experiment. Sarcomere length of the *m. longissimus dorsi* (LD) was determined 48 h post-mortem. The fore-rib joint was allowed to age for 7 days post-mortem, in a cold room at 2^{o}C, before the LD muscle was removed. Ultimate pH, colour, Warner Bratzler shear force (WBSF) and cooking loss were determined 7 days post-mortem using the methods detailed by Moss *et al*. (1993). Data were analysed as a 2 (gender) x 3 (planes of nutrition during the growing phase) x 3 (planes of nutrition during the finishing phase) experiment using Genstat analysis of variance.

Results Animal performance data from this study have been presented by Keady *et al*. (2004). Mean carcass weights were 306, 322 and 329 (sed 4.0) kg for Low, Medium and High GPD treatments; 304, 317 and 337 (sed 4.0) kg for Low, Medium and High FPD treatments, and 307 and 331 (sed 4.3) kg for heifers and steers, respectively. The corresponding fat classes (1=lean and 5=fat) were 3.45, 3.41 and 3.64 (sed 0.126) and 3.29, 3.55 and 3.66 (sed 0.126) and 3.35 and 3.65 (sed 0.138) respectively. The effects of gender and concentrate feeding level on meat quality are presented in Table 1. Plane of nutrition during the indoor growing phase or indoor finishing phase and gender had no effect (P>0.05) on meat quality as assessed by colour (L*, a* and b*), sarcomere length, ultimate pH, cooking loss or Warner Bratzler shear force.

Table 1 The effect of gender and plane of nutrition during the winter growing and finishing phases on meat quality.

	Gender (G)			Growth phase diet (GPD)			Finishing phase diet (FPD)			
	Steer	Heifer	sed	Low	Med.	High	Low	Med.	High	sed[1]
Colour										
L*	39.7	37.7	1.150	38.4	38.1	39.6	38.7	38.4	39.0	1.357
a*	21.2	21.6	0.692	21.0	22.0	21.2	21.5	21.8	20.9	0.816
b*	13.1	13.5	0.451	13.0	13.6	13.2	13.0	13.6	13.2	0.532
Sarcomere length (mm)	2.56	2.64	0.056	2.55	2.64	2.61	2.59	2.58	2.63	0.066
Ultimate pH	5.60	5.60	0.008	5.60	5.60	5.60	5.59	5.61	5.59	0.009
Cooking loss (%)	25.4	26.3	0.640	26.6	25.8	25.3	26.6	26.1	25.0	0.757
WBSF (kg/cm^2)	2.23	2.29	0.088	2.36	2.18	2.24	2.24	2.28	2.26	0.104

[1] There were no significant (P>0.05) effects of G, GPD and FPD, or GPDxFPD, GxGPD, GxFPD and GxGPDxFPD interactions on meat quality

Conclusions It is concluded that altering the rate of growth during the growth phase and finishing phase indoor feeding periods, or gender had no significant effects on meat quality.

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Effect of dietary polyunsaturated fatty acids on gut mucosal mast cells in calves

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Introduction Polyunsaturated fatty acids (PUFA), especially the n-3 and n-6 families are dietary compounds with significant immunomodulatory potential. Mechanisms proposed to explain their impact on immune function include (1) direct effects on leukocyte and epithelial cell membrane function, (2) the regulation of expression of immune genes and their products and (3) eicosanoid-mediated mechanisms (Hwang, 2000). Eicosanoids are immune effector molecules which have important roles in the regulation of immune and inflammatory responses (Calder, 2001). The aim of this experiment was to establish the extent to which supplementation of pre-ruminant calves with an n-6 or n-3 PUFA source may influence mucosal mast cell numbers in the abomasum (ABO), duodenum (DD) and terminal ileum (TI).

Materials and methods Forty male Jersey calves were allocated at birth to 7 treatment groups. Group A; 4 calves, fed colostrum according to the normal farm practice. Calves were slaughtered when 4 days old. Groups B-G (n= 6), were fed colostrum for 4 days and were then allocated to milk (M) or milk replacer (MR) without supplemental oil (groups B and C), with 25g fish oil (FO) /day (groups D and E) or with 25g of a binary mixture (50:50 w/w) of palm/ rapeseed oil (PRO) (groups F and G) for a further 21 days. 30-mg α-tocopherol acetate/kg PUFA was given to all the calves receiving the oil supplement. Samples of ABO, DD and TI were obtained for immunohistochemical determination of mucosal mast cells using the method described by Vervelde et al, (2001). The counts were performed on 10 different areas of view and expressed as mean cell numbers per 0.2 mm^2. Data was analysed by ANOVA using the General Linear Model (GLM) (Minitab 13.0, Mintab, Inc, PA. USA). Significant differences were reported at $p<0.05$.

Results Calves fed on colostrum and slaughtered at day 4 (group A) had significantly lower numbers ($p<0.01$) of mucosal mast cells (MMC) in the DD when compared to all the other groups. In the ABO there were no significant treatment differences ($p>0.05$) in the MMC numbers. However, in the DD calves fed on whole milk or milk replacer with additional fish oil (groups D and E) had lower MMC numbers when compared to the palm/rapeseed oil fed calves (groups F and G). In the TI, there were no significant differences in MMC numbers between colostrum and whole milk fed calves (group A vs B). MMC numbers were significantly lower ($p<0.05$) in calves fed on whole milk (group B), when compared to milk replacer fed calves (group C). Addition of a binary mixture of palm/rapeseed oil in whole milk (group F) increased the numbers of MMC to levels similar to those observed in milk replacer fed calves (group C). The highest number of MMC in the TI was in calves fed on the binary mixture of palm/rapeseed oil in milk replacer (group G). Overall, the ABO had markedly few MMC numbers when compared to the DD and TI irrespective of the oil supplement.

Table 1 Effect of feeding calves on colostrum, whole milk or milk replacer with additional fish oil or a binary mixture of palm/rapeseed oil on mucosal mast cell numbers (mean cells/10 areas of view).

Sample	Colostrum Group A (n=4)	Milk Group B (n=6)	MR Group C (n=6)	M +FO Group D (n=6)	MR +FO Group E (n=6)	M+PRO Group F (n=6)	MR+PRO Group G (n=6)
ABO	2.8±0.9	3.3 ±0.7	5.1 ±0.8	2.8 ±0.7	3.3 ±0.7	4.6 ±0.7	4.8 ±0.7
DD	4.3^{a}±1.8	8.4^{b}±1.4	12.4^{b} ±1.5	13.6^{b}±1.5	13.9^{b}±1.5	15.9^{c}±1.4	21.2^{d}±1.4
TI	6.6^{a}±1.9	8.7^{a}±1.5	14.3^{c} ±1.6	12.6^{b} ±1.6	14.9^{c} ±1.6	17.8^{c} ±1.5	24.4^{d} ±1.5

Values are means ± SEM. Means with different superscripts on the same row are significantly different ($p<0.05$).

Conclusions The responses in the day 4 old calves fed only colostrum (group A) maybe indicative of an age related hyporesponiveness. Fish oil, an n-3 PUFA source appears to reduce the MMC numbers, while feeding an n-6 PUFA source (PRO) appears to increase the MMCs numbers in this study. Because n-3 PUFA derived eicosanoids have different potencies to those derived from n-6 sources, it is probable that the differences in recruitment of MMCs is mediated by changes in eicosanoid profiles due to provision of different precursor fatty acids. This could be used as an immunonutritional strategy to optimise the gut mucosal immune response to gut parasite infections and to minimise tissue damage and metabolic costs associated with acute inflammatory response.

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Influence of replacement rate on the welfare of sows introduced to a large dynamic group

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Introduction Dynamic grouping systems for sows involve the regular replacement of sows which are due to farrow with those that have just been mated. Evidence suggests that newly-introduced sows are often subjected to high levels of aggression from 'resident' sows in dynamic groups (O'Connell *et al*., 2003). In addition, newly-introduced sows often appear intimidated from using kennel areas and are forced to lie on less-preferred slatted dunging areas (Moore *et al*., 1993). The aim of the present study was to assess the effect of replacing 10, 20, 30 or 40 percent of a group of forty sows on the welfare of sows newly-introduced to the group.

Materials and method Two hundred LW x Lr multiparous sows were allocated to one of four treatments over five replicates. Treatments were applied at 3 week intervals and are described as follows: (1) one group of four sows added to dynamic group, (2) two groups of four sows added to dynamic group, (3) three groups of four sows added to dynamic group, and (4) four groups of four sows added to dynamic group. Each group of four sows was formed directly after weaning (day 1), were artificially inseminated on day 5 and transferred to the dynamic group on day 33. Three days prior to the sows being added to the dynamic group, the same number of animals were removed from the group. The dynamic group consisted of 40±2 sows, therefore treatments (1) to (4) equated to replacement rates of 10, 20, 30 and 40 percent of the group, respectively. The dynamic group of sows was housed in a split-yard system (18.2 x 7.8 m) with three kennels in yard 1 and three kennels in yard 2. Both yards contained a slatted exercise and drinking area. Yard 1 was separated from yard 2 by an electronic feed station. Behaviour of newly-introduced sows was recorded continuously in real time by video cameras during the first 7 days after they were added to the dynamic group. Instantaneous scan samples were made at 1 hour intervals over this 7 day period. These scans were used to identify whether newly-introduced sows were lying, sitting or standing in either kennel or slatted areas. If sows were lying, then whether or not they were lying in contact with another sow (newly-introduced or 'resident' sow), or lying more than 0.5 m away from a wall was assessed. Aggressive behaviour towards newly-introduced sows was observed from video recordings for continuous 5 min periods each hour between 1100 and 1600 hours on the day that sows were added to the dynamic group. Aggression-related injury scores were measured from sows 1 week post mixing. Data were analysed by analysis of variance using Genstat 5.

Results Effects of replacement rate on selected parameters are listed in Table 1. Newly-introduced sows in the 10 percent replacement rate treatment spent more time in slatted areas and less time in kennel areas during the first week post mixing than newly-introduced sows in other treatments ($P<0.05$). When sows in the 10 percent replacement rate treatment entered kennel areas, they spent less time lying down ($P<0.05$), and when they did lie down they spent less time lying in contact with other sows and less time lying away from the wall compared with newly-introduced sows in other treatments ($P<0.05$).

Table 1 Influence of replacement rate on the average proportion of time spent in different locations and behaviours by newly-introduced sows during their first 7 days in a large dynamic group

Parameter	Percent replacement rate				s.e.m.	Significance
	10	20	30	40		
Slatted area	0.464[b]	0.199[a]	0.157[a]	0.165[a]	0.0770	*
Kennel area	0.530[a]	0.797[b]	0.841[b]	0.833[b]	0.0770	*
Within kennel areas:						
Lie	0.673[a]	0.836[b]	0.841[b]	0.881[b]	0.0438	*
Lie in contact with another sow	0.600[a]	0.780[b]	0.743[b]	0.812[b]	0.0408	*
Lie away from wall	0.166[a]	0.394[b]	0.320[b]	0.259[b]	0.0497	*

Replacement rate did not significantly affect levels of aggression to which newly-introduced sows were exposed at mixing, or injury levels at 1 week post mixing. In all treatments, newly-introduced sows showed a significant increase in the time spent in kennel areas, and the time spent lying in contact with 'resident' sows during the first week post mixing ($P<0.05$).

Conclusions Replacing 10 percent or less of a dynamic group of 40 sows may compromise the welfare of newly-introduced sows. However, there does not appear to be any additional welfare benefit associated with increasing replacement rates above 20 percent. The increased use of resident sows as lying partners in all treatments during the first week post mixing suggests that new sows begin to socially integrate with the resident group during this period.

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Influence of replacement rate on the welfare of sows introduced to a large dynamic group

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The influence of different early life enrichment on the behaviour of pigs on an Elevated Plus Maze

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Introduction Providing environmental enrichment to farmed animals such as pigs is very important to safeguard their welfare. Current legislation specifies that all pigs must have permanent access to a sufficient quantity of material to enable proper investigation and manipulation activities. Straw has always been regarded as a functional form of enrichment for pigs, but can be difficult to use in slatted housing systems. Alternative enrichment objects might be acceptable substitutes, provided they are designed according to characteristics which pigs find important (Van de Weerd *et al*., 2003), as pigs may lose interest in simple devices. Most enrichment studies have focussed on immediate effects on behaviour, but it is also important to find out whether there are critical periods where providing enrichment will have effects later in life. The aim of the present study was to investigate whether early life enrichment had an effect on the behavioural development of pigs. To assess this, pigs were tested on an Elevated Plus Maze (EPM) at 10 weeks of age. The EPM is a well-validated anxiety model in rodents, which has more recently been used in pigs. It provides a way to separate fear of novelty (avoidance of open arms) and activity-related elements (entries into closed arms) (Anderson *et al.*, 2000).

Materials and methods Forty-eight litters of Large White–Landrace crossbred pigs were used in a 2x4 factorial experiment. Four enrichment treatments were provided for a four-week period starting either, immediately post-partum (the suckling period), or immediately post-weaning. The four treatments were 1) Object 1 providing variable, particulate substrates to the pigs 2) Object 2 providing chewing and gustatory stimulation 3) a barren environment (negative control) 4) a full bed of chopped straw (positive control). At 9-10 weeks of age, two focal animals (one female, one male) from each of the litters (n=96) were subjected to an EPM test. The EPM consisted of two open arms measuring 150x90 cm and 2 closed arms (measuring 150x90x60 cm, walls of perspex) and a middle section (90x90 cm). The whole maze was raised 90 cm above floor level. Animals were tested individually for 5 minutes, during which their behaviour and location were scored. Behaviour was analysed with ANOVA and location with paired t-tests.

Results No main differences were found between pigs receiving enrichment in the two treatment periods (post-partum and post-weaning). Animals from all treatments spent more time on the open arms than on the closed arms or the middle of the maze (mean sec ± s.e., open 130.6±4.03, closed 105.5±3.89, middle 62.5±3.27, all $P<0.01$), but animals from the straw treatment distributed time more evenly, spending less time on the open arms in comparison with animals from the barren or Object 2 treatments (Table 1). The meta-category 'investigate' (= all behaviours involving nosing the maze) showed that in the middle section, pigs from the straw treatment investigated the maze longer than pigs from the barren or Object 2 treatments (Table 1). They also had shorter sessions of non-investigation on the open arms as compared with animals from the barren or Object 2 treatments (Table1). Overall, pigs from the straw treatment stood and nosed the floor for longer than pigs from the barren treatments, this was also found for the middle section. They also walked nosing the floor for longer in the middle section than pigs from barren or Object 2 treatments (Table 1).

Table 1 Main differences in the duration (sec) of behaviour of pigs with different enrichment backgrounds on an EPM

Behaviour	*Location*	Barren		Object1		Object2		Straw	
Total time	open arms	139.6^{a}	(7.50)	131.8	(7.67)	140.2^{a}	(7.97)	110.9^{b}	(7.32)
Investigate	middle	16.8^{a}	(4.34)	24.2	(4.43)	24.8^{a}	(4.61)	39.0^{b}	(4.24)
Non-investigation	open arms	47.3^{a}	(5.43)	36.4	(5.55)	45.3^{a}	(5.77)	32.1^{b}	(5.30)
Standing nosing floor	overall	90.8^{a}	(5.53)	111.1	(5.66)	103.4	(5.88)	115.3^{b}	(5.41)
Standing nosing floor	middle	8.1^{a}	(3.18)	12.6	(3.25)	13.2	(3.38)	23.6^{b}	(3.10)
Walking nosing floor	middle	7.0^{a}	(1.46)	10.6	(1.49)	9.3^{a}	(1.55)	14.6^{b}	(1.43)

Mean and (s.e.); ^{ab} means within a row with different superscripts differ significantly at $P<0.05$.

Conclusions The EPM showed that enrichment provided early in life influenced the behaviour of the pigs and the main contrasts were found between pigs from straw and barren treatments. Pigs from the straw treatment used the maze more uniformly and spent more time investigating the maze. This suggests that the provision of straw early in life modified exploratory behaviour as measured on the EPM. Of the two enrichment treatments, effects of enrichment with particulate substrates (Object 1) more closely resembled straw.

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Effects of habituation to the milking parlour on milking behaviour of Norwegian and Holstein dairy herd replacements

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Introduction Previously reported results indicate that milk production and somatic cell counts were improved by the habituation of replacement heifers to the milking parlour prior to calving (Wicks, *et al* 2003). Rushen, *et al.* (2001) reported that when mature cows were milked in unfamiliar surroundings, milk yield, milk flow rate and milking duration were affected due to increased stress (Rushen, *et al.* 2001). The objective of the current study was to investigate the effects of habituating Holstein-Friesian and Norwegian heifers to the milking parlour pre-calving on subsequent milking parlour behaviour.

Materials and Methods Fifty-four spring calving heifers (32 Holstein-Friesian and 22 Norwegian (NRF) dairy cattle) were used in a study to investigate the effects of habituating heifers to the milking parlour prior to calving. The average genetic merit for Holstein-Friesian and Norwegian replacements were 35.9 (s.d. 5.79) PTA_{2000} and 11.7 (s.d. 2.17) Total Merit Index respectively. Treatment 1 animals were introduced to the milking parlour (20-point rotary herringbone parlour) 3-weeks prior to calving (Habituation group), whereas Treatment 2 animals were introduced to the parlour post-calving (Control group). Prior to calving, heifers were housed in two groups in adjacent cubicles within the same building. Behaviour records (including flinch, step and kick, and general restlessness ie tail swishing) were recorded from real time video recordings of the entire milking process for both AM and PM milkings during the first 3 weeks of lactation. The data were analysed using repeated measures REML analysis and fixed effects included week of lactation, breed, treatment and their interactions.

Results Holstein-Friesian heifers yielded more milk compared with Norwegian dairy heifers (*P<0.001*), and heifers in the habituation treatment yielded 1.5 kg/d more milk compared with heifers in the control group (*P<0.001*) (First 100 days lactation). Milk flow rates and somatic cell counts were significantly lower in the habituation group compared with the control group (*P<0.001*). There were no significant differences in the number of flinch, step and kick behaviours recorded for animals in the control compared with the habituated group, however habituated heifers were shown to have significantly higher step, flinch and step, and flinch, step and kick rates (steps/second) compared with control heifers (Table 1). The difference between habituation and control group heifers was not significant by 2 weeks post calving. Total number of flinch, step and kick behaviours per milking and the rate of flinches and kicks were not significantly different between the two breeds, however the rate of steps, flinch and step, and flinch, step and kick behaviours were significantly higher for the Holstein-Friesian heifers compared with the Norwegian dairy heifers.

Table 1: Production and milking traits of first calving Holstein-Friesian and Norwegian heifers during the first 100 days of lactation by breed and treatment (There were no breed by treatment interactions).

	Breed			Treatment			
	Holstein	Norwegian	sig	Control	Habituation	sig	s.e.d
Milk Yield (kg/d)	27.4	25.0	***	25.4	26.9	***	0.27
Somatic Cell Count (log_{10})	1.78	1.68	**	1.78	1.66	***	0.037
Milk Flow Rate (kg/min)	2.37	2.17	***	2.35	2.20	***	0.041
Behaviour							
Flinch (Total per milking)	0.96	0.96	NS	0.91	1.01	NS	0.125
Step (Total per milking)	7.58	6.73	NS	6.37	7.94	NS	0.996
Kick (Total per milking)	1.49	1.51	NS	1.41	1.60	NS	0.485
Flinch (counts/s)	0.003	0.003	NS	0.003	0.003	NS	0.0087
Step (counts/s)	0.022	0.014	**	0.014	0.022	**	0.0031
Kick (counts/s)	0.004	0.003	NS	0.003	0.004	NS	0.0011
Flinch and Step (counts/s)	0.025	0.017	*	0.017	0.025	*	0.0032
Flinch, Step and Kick (counts/s)	0.028	0.020	*	0.019	0.029	**	0.0035
Restlessness (counts/s)	0.049	0.036	*	0.040	0.045	NS	0.0057

Conclusion Allowing heifers to become accustomed to the milking parlour prior to first calving increased milk production and reduced somatic cell counts, suggesting a reduction in stress in animals habituated to the milking parlour. Although the total number of observed behaviours were not significantly different for heifers in either treatment, the rate of behaviours per second were higher for the habituated heifers. The results suggest that introduction to the milking parlour prior to calving has no long term adverse affects on milking behaviour but does have positive effects in terms of production and health. In this study the results indicated that the Norwegian heifers were calmer compared with Holstein-Friesian heifers.

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Preference by goats for browse species in response to changing post-ingestive consequences

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Introduction Browsing herbivores tend to feed selectively, focussing on nutritious species and plant parts and avoiding toxic components. Recent research suggests that this selective browsing is substantially dependent on learning about post-ingestive consequences. Thus, animals come to associate particular foods with particular effects through experience and subsequently adjust their preference accordingly. Most previous experiments have involved simple training tasks (e.g. Burritt and Provenza, 1992) which do not reflect the complexity of the diet choice problem for free-ranging herbivores. A series of experiments was conducted testing the following more realistic food choice scenarios: (1) simultaneous vs temporally separated presentation of food options during the learning phase (2) seasonal change in post-ingestive consequences and (3) trade-offs between positive and negative consequences arising from single feeds.

Materials and methods Goats were offered fresh conifer species as test feeds (Douglas fir (*Pseudotsuga menziesii*), Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*) or Sitka spruce (*Picea sitchensis*)). Lithium chloride, which induces mild nausea, was used as a negative stimulus simulating the aversive effects of plant toxins. Lithium chloride has been widely used in experiments of this type (Gustavson, 1977) since its effects are mild and temporary. Sodium propionate was used as the positive stimulus simulating enhanced fermentation in the rumen. Separate conifer species were offered on consecutive days during a training phase and animals were simultaneously dosed with post-ingestive stimuli depending on treatment. After a series of training days a preference test was conducted to assess learning. The whole process was then repeated for a number of periods. In the first experiment single conifer species were offered on separate training days, each associated with either a positive, a negative or a neutral post-ingestive consequence. The ability of animals to learn about post-ingestive consequences was compared with animals offered the same species simultaneously. In the second experiment, each of 4 conifer species was associated with either positive or negative consequences that either declined or increased with time over 6 weeks to simulate seasonal change in food quality. In the final experiment each of 4 conifer species was associated with a different combination of positive or negative consequences such that trade-offs between positive and negative consequences could be investigated. Data were analysed by fitting REML models to separate out within- and between-goat variation, assuming the logratios with respect to Sitka spruce followed a 3-variate Gaussian distribution.

Results Simultaneous presentation of feeds during the learning phase considerably compromised goats' ability to learn about which feeds were associated with different post-ingestive consequences (Fig 1a). When feeds were well separated in time, goats were able to monitor simulated seasonal change in negative consequences and adjust their diet selection accordingly (Fig 1b). The evidence for animals' ability to monitor change in nutritional rewards was less convincing. When individual foods were associated with a combination of positive and negative consequences, diet choice was dominated by avoidance of negative consequences (Fig 1c).

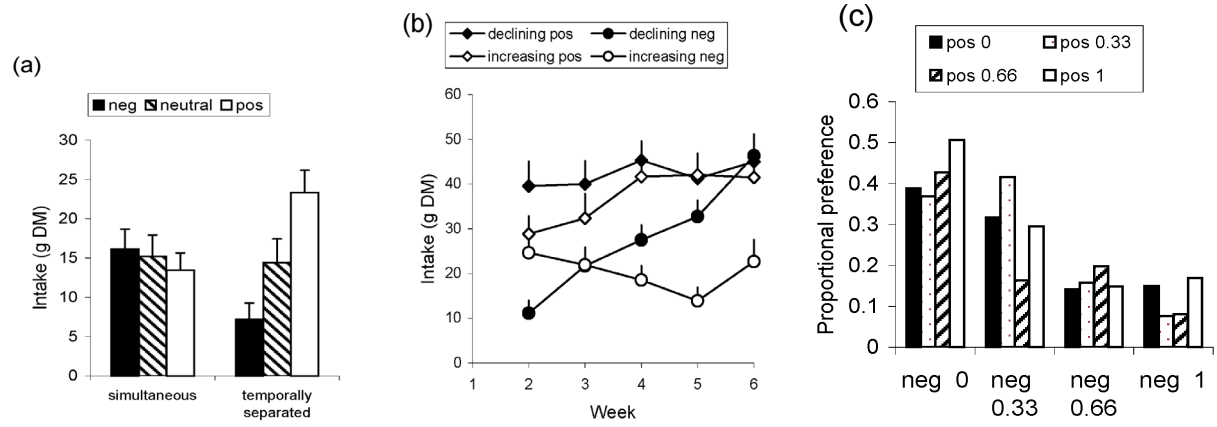

Figure 1. The effect of oral administration of LiCl (neg), NaCl (neutral) or sodium propionate (pos) on preference for associated browse. In (a), different browse species were offered on 3 separate days (temporally separated) or all 3 were offered every day (simultaneous) during the learning phase. In (b) the rate of administration of pos and neg were increased or decreased in regular increments each week. In (c) each of 4 browse species was associated with a combination of pos and neg stimuli to examine trade-offs.

Conclusions Goats can learn to associate post-ingestive consequences with individual browse species although this ability is reduced in complex diet choice situations akin to those found under natural free-ranging circumstances. The learning response is sufficiently flexible to cope with seasonal change in food characteristics. Avoidance of negative consequences appears to dominate diet selection outcomes when complex diet choice scenarios are presented.

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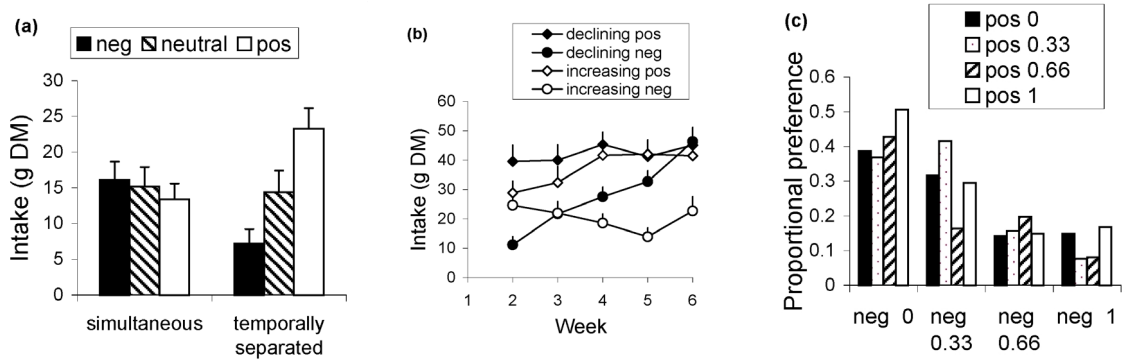

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The direction of facial hair whorl rotation may be a useful indicator of lateralised behavioural preferences in the horse.

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Introduction There have been numerous studies of laterality (handedness, sidedness or lateralised motor behaviour) involving several species including humans, primates, dogs, cats, rodents, whales and horses. In humans for example, population bias of the order of 93% for right-handedness has been reported from studies of more than 5000 years of art work, which appears to be unaffected by culture or geographic location. It has long been accepted that the majority of horses are lateralised (to varying degrees) and training programmes have been designed to 'straighten' the lateralised competition horse, (Klimke, 2003). The specific cause of laterality in any species still remains open to some degree of debate and theories of genetic predisposition, environmental influences and combinations of both have been proposed. While both environmental and genetic models have been suggested with regard to the aetiology of lateralised behaviour, mapping of any specific locus, which could be unequivocally attributed to lateralised behaviour is as of yet incomplete. There is evidence suggesting a relationship between facial hair whorls and side preferences from studies in cattle, Tanner et al., (1994). Dalin et al., (1985) reported that laterality and asymmetry in equine motor behaviour may negatively affect locomotion and subsequently compromise competitive performance. The objective of this study was to explore the possibility of predicting the direction of lateral bias in the horse from observations of the direction of facial hair whorl rotation.

Materials and methods We investigated the relationship between the direction of facial hair whorl rotation and the incidence and direction of laterality in 67 horses (males = 35, females = 32). The animals were Thoroughbred breed or sport horse types, aged between 3 and 7 years, (mean ± S.E.: 5.4 ± 0.6) and the male horses comprised of geldings (n = 31) and stallions (n = 4) while females were all non-pregnant mares. The horses were all potential high performance animals and they were all actively in training for competitive careers in some discipline of equitation. Animals with multiple or abnormal hair whorls were not considered and only horses with one facial hair whorl were measured for participation in the study. The horses' facial features were examined and photographed from directly in front of the animal at eye level. The direction of the facial hair whorl rotation was assessed as either radial (R), clockwise (C) or counter clockwise (CC), Figure 1. The trainers in the current study had sufficient experience in producing high-class competition horses over many years and they rated the horse in terms of motor asymmetry as (1) left lateralised, (2) right lateralised or (3) equally balanced, based on the horse's training and performance history.

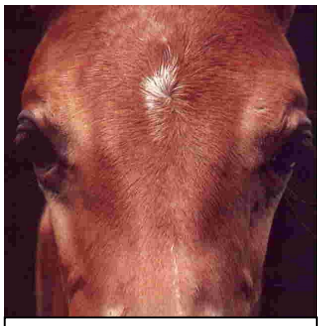

Figure 1. A horse with a clockwise facial hair whorl

Results The data were statistically analysed by means of tests of association and simple linear regression. Tests of association between variables revealed that there was a significant association ($\chi^2 = 7.58$, d.f. = 2, $P < 0.02$) between the direction of laterality of the horses and the direction of the facial hair whorl rotations, Table 1. Note: Equally balanced horses were omitted from the analysis due to the sample size so as to maintain validity with respect to expected counts. Left lateralised horses had significantly more facial hair whorls with counter clockwise (CC) rotation than that expected by chance. Similarly, right lateralised horses had significantly more facial hair whorls with clockwise (C) rotation than that expected by chance. There was no difference in the distribution of radial facial whorls in the horses rated as lateralised. Simple linear regression analysis revealed that the direction of facial hair whorl rotation accounted for 34% of the prediction regarding the direction of laterality reported in the individual horses, (R = .34, $F_{1,65}$ = 8.25, $P <$ 0.01) and was therefore a salient predictor.

Table 1

	Facial hair whorls			Total
Laterality	(CC)	(C)	(R)	
Left lateralised	18	6	5	29
Right lateralised	9	16	6	31
Equally balanced	2	0	5	7
Total	29	22	16	67

Conclusions The findings of the present study suggest that assessing the direction of facial hair whorl rotation may be a useful indicator of lateralised motor behaviour in the horse. This may assist enlightened trainers to design individual specific training programmes for young horses. Whorl and hair pattern manifestations have been linked to early foetal brain development in humans and further study of facial hair whorl rotation and placement may provide useful insight into both behavioural and neurobiological development in the horse.

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The 'peanut shuttle': the effect of a feeding device on stereotypy and foraging behaviour in captive female Asian elephants (*Elephas maximus*)

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Introduction Elephants are long lived, apparently highly intelligent mammals with complex social structures and large home ranges (e.g. median 113km^2 for Asian elephants). There are over 1700 elephants housed in captivity world-wide, of which over 1000 are kept in Zoos as part of an actively managed conservation breeding programme, associated educational activities and benign scientific research aimed at improving breeding and welfare (Stevenson 2002). However, a recent RSPCA report (Clubb and Mason 2002) has suggested that there are serious welfare issues associated with keeping these large essentially herbivorous mammals in captivity. For instance, wild elephants spend between 60-80% of their waking hours feeding and foraging and will migrate in pursuit of food but in Zoos foraging accounts for only 30-40% of an elephant's waking time budget. Animals that are prevented from performing highly motivated behaviours, such as feeding, may be prone to develop stereotypic (repetitive, apparently functionless) behaviour. The objective of this study was to evaluate the efficacy of a specially designed elephant feeding device, the peanut shuttle, in increasing foraging time and decreasing stereotypy in a group of Asian elephants, *Elephas maximus*, housed within Blackpool Zoological Gardens.

Materials and methods Four female Asian elephants, *Elephas maximus*, were used in this study conducted between December 2002 and April 2003. The elephants, aged between 31 and 37 years, formed an established social group housed together since 1999. Three of the four elephants were known to exhibit stereotypic behaviour. Their enclosure consists of an indoor and outdoor exhibit to which they had free access during the day except for brief, regularly timed, periods when routine management procedures occurred.
The peanut shuttle feeder is an aerial device which was specially designed to a) be strong enough to withstand being used by a four tonne animal and b) to encourage manipulation by the elephants using their trunks, encouraging natural foraging movements. During the study the device was securely suspended between two walls of the indoor enclosure using industrial metal cable, running through the body of the device, enabling it to spin and move laterally along the cable. The wooden body of the device was peppered with holes with an access hatch to allow regular filling with peanuts from the daily ration (immediately prior to observations). The flow of peanuts out of the device is impeded by golf balls contained within the device, prolonging emptying time.
The behaviour of the elephants was observed using scan sampling at five minute intervals, during the same hour every day, over the three phases of the study (pre-device installation, with the device *in situ* and post-device removal). Ten hours worth of data was gathered during each phase of the study.

Results
Though only the matriarch directly manipulated the device, overall a significant increase in feeding and foraging behaviours was observed when the peanut shuttle was *in situ* (ANOVA f?,?? = 136.01, P<0.001) as the spray of peanuts onto the enclosure floor allowed all to access the feed. No increase in social behaviour of either a positive or negative nature was seen (Kruskal-Wallis H?=1.13 NS). Stereotypic behaviours were reduced in the 3 individuals known to exhibit them (ANOVA f?,?? = 9.34, P<0.025).

Conclusions The results of the present study demonstrate that the use of specially designed feeding devices can assist in extending foraging time in captive elephants. However, because of the small sample size in this study and the very variable nature of elephant environments in different zoos, such enrichments need to be carefully evaluated for efficacy on a zoo by zoo basis.
Although a direct causal link between foraging and stereotypy in elephants has not been established, by increasing foraging time in this study stereotypy was decreased during the observational period. However this device was only made available to the elephants for one hour a day, in part to fit in with husbandry regimes and availability for observations but also to avoid habituation to the device, a common problem when introducing enrichment into captive / domesticated animal environments. The long term efficacy of this enrichment in achieving our objectives is yet to be determined. However in order to substantially extend foraging time in captive elephants a variety of feeding enrichments that can be rotated is likely to be required.

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The genetic correlation between parasite resistance and sheep production traits across a range of environments using random regression

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Introduction Breeding for increased intestinal worm resistance using faecal egg count (FEC) as an indicator trait has been implemented in several sheep industries. The research on which this development is based has been carried out on resource flocks with only limited information on how the same genotype performs under a wide range of conditions. Pollott and Greeff (2004a), using industry Merino data from Australia, have reported genetic correlations between FEC and sheep production traits to be zero. The only exceptions were fat depth (FAT), eye-muscle depth (EMD) which were moderately negatively correlated. Whilst investigating the genotype by environment interactions in this dataset Pollott and Greeff (2004b) described the way in which the heritability of FEC and production traits varied in a wide range of flock environments. This paper reports how the genetic correlations between FEC and production traits vary across a range of FEC environments.

Materials and methods The flocks and dataset used in this study have been described by Pollott and Greeff (2004a). Briefly they comprise 55 commercial Merino flocks from four states in Australia which have been recording FEC since the early 1990s. Data were available, from 127,723 animals, on a range of fleece and body traits. This paper reports the results for fibre diameter (FD), greasy fleece weight (GFW), FAT and EMD and their genetic correlation with FEC ($\sqrt[3]{}$eggs/g of faeces) in a range of FEC environments, defined as the mean FEC value for the contemporary groups (CG) found in the dataset. A CG was defined as all animals in a flock, year, sex and age group. A sire model was fitted to the data using the reaction norm approach of Kolmodin et al (2001). Four bivariate analyses were carried out between the production traits and FEC, using mean CG FEC as the environmental variable on which the sire's value was regressed. Each variable was fitted using the final models reported by Pollott and Greeff (2004a). Fibre diameter was chosen because it was the most widely recorded trait, GFW because of its importance in the sheep industry and the two body traits because they were found to be significantly correlated with FEC .

Results and discussion The distribution of FEC CG means is shown in Figure 1. The results of fitting the bivariate random regression model to the four traits and calculating the genetic correlations across the FEC environments are shown in Figure 2. The standard errors of the estimates ranged from 0.04 (GFW and FD) to 0.09 (FAT and EMD) at the centre of the environmental range but increased at the extremes.

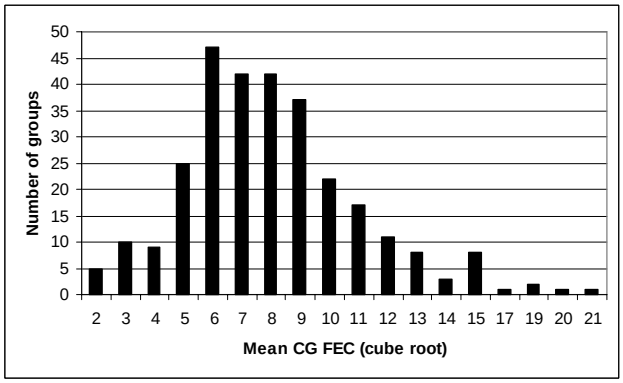

Figure 1 Distribution of mean CG FEC

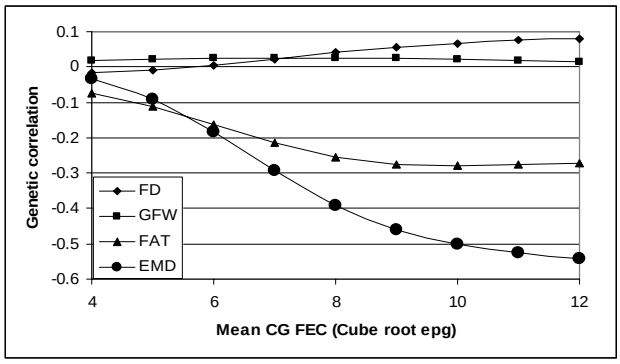

Figure 2 The genetic correlation of 4 traits with FEC

The point estimates of the four overall genetic correlations with FEC (Pollott and Greeff, 2004a) were –0.031±0.0438 (FD), 0.038±0.0473 (GFW), -0.256±0.0877 (FAT) and –0.183±0.0912 (EMD).

Conclusions The low point-estimate genetic correlations found for both FD and GFW were reflected across the range of FEC environments analysed. The genetic correlation of FEC with the two body traits increased in magnitude (negatively) as the FEC environment deteriorated. Breeding for reduced FEC in good environments is unlikely to affect any of the 4 production traits studied. However, in poor FEC environments there is likely to be a correlated increase in fat and muscle depth. However, since this is likely to lead to a better 'FEC environment' as well, the correlated response will decrease over time.

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Genetic relationships between indicator traits and parasitic nematode infection in sheep

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Introduction Grazing sheep are invariably subjected to natural nematode parasitic challenge. Anthelmintic resistance is becoming widespread among parasites and alternative control measures are urgently needed. A potential alternative control method is breeding for improved resistance (Woolaston and Windon, 2001). The aim of this study is to investigate the genetic control of the component traits of parasite infection (worm length, worm burden and worm fecundity) and indicator traits of infection, and quantify genetic relationships between these traits. Indicator traits investigated in this study are fructosamine concentration, immunoglobulin A (IgA) activity, eosinophil counts and pepsinogen concentration. Fructosamine concentration reflects average glucose and protein concentrations and rates of protein turnover. IgA is a secreted antibody and is of key importance in gut infections. Eosinophils are a type of white blood cell associated with parasitic infection. Pepsinogen is a digestive enzyme precursor, which increases concentration in the plasma following the breakdown of intercellular junctions in the abomasum.

Methods 1000 Scottish Blackface lambs, predominantly twins, were studied over a 5-year period (1992-6). All lambs were born outside, during last 2 weeks of April and 1st week of May, and were continuously exposed to mixed nematode infections by grazing. Every 28 days from 4 to 20 weeks of age all lambs were treated with a broad spectrum anthelmintic (albendazole sulphoxide), at the dosage rate recommended by the manufacturer. Blood samples were collected 28 days post the final anthelmintic treatment. IgA, pepsinogen, eosinophil and pepsinogen concentrations were measured from these samples. Approximately half of each cohort was slaughtered at 6-7 months of age (6-7 weeks post final anthelmintic treatment). At slaughter standard parasitological procedures were used to enumerate *Teladorsagia circumcincta* nematodes in the abomasum (Armour, Jarrett and Jennings 1966), and average worm length and the number of eggs *in utero* were estimated on at least 25 adult female worms from each lamb. All traits, except worm length and fructosamine, were skewed and were log-transformed prior to analysis. The data was analysed using restricted maximum likelihood (REML) to estimate heritability values and also to calculate the genetic, phenotypic and environmental correlations between the parasitological and indicator traits.

Results Worm length and fecundity were both highly heritable (Table 1), but worm burden had a low heritability. The indicator traits were all moderately to highly heritable, with significant litter effects observed for fructosamine and pepsinogen. Phenotypic correlations between indicator and parasitological traits tended to be low (Table 2), with the genetic correlations usually being stronger. This discrepancy is explained by the environmental correlations being either close to 0 or opposite in sign to the genetic correlations. Fructosamine exhibited a positive genetic correlation with both worm length and fecundity, however for IgA, eosinophil and pepsinogen negative genetic correlations were observed. Strong negative genetic correlations between IgA and parasitological traits suggest that the ability to produce high levels of IgA may help animals combat parasitic infection, however positive environmental correlations suggest that high values are also diagnostic of infection. Genetic correlations with worm burden had s.e.s that were too large for meaningful interpretation and hence are not shown.

Table 1 Estimates of heritabilities (h^2) and litter effects (c^2) for parasitological and indicator traits

Trait	h^2	s.e.	c^2	s.e.
Worm Length	0.53	0.17		
Worm Fecundity	0.50	0.16		
Worm Burden	0.13	0.10		
Fructosamine	0.39	0.16	0.21	0.07
IgA	0.57	0.15		
Pepsinogen	0.56	0.16	0.12	0.07
Eosinophil	0.35	0.15		

Table 2 Genetic, phenotypic and environmental correlations between indicator traits and necropsy data

Trait	Re (se)	Rp (se)	Rg (se)
Worm Length – Fructosamine	-0.27 (0.24)	0.17 (0.06)	0.67 (0.27)
Worm Length – IgA	0.27 (0.27)	-0.15 (0.07)	-0.53 (0.24)
Worm Length – Pepsinogen	-0.09 (0.23)	-0.30 (0.05)	-0.48 (0.21)
Worm Length – Eosinophil	-0.05 (0.21)	-0.28 (0.07)	-0.58 (0.27)
Worm Fecundity – Fructosamine	-0.19 (0.37)	0.14 (0.04)	0.31 (0.24)
Worm Fecundity – IgA	0.42 (0.26)	-0.07 (0.07)	-0.62 (0.26)
Worm Fecundity – Pepsinogen	-0.30 (0.22)	-0.26 (0.05)	-0.26 (0.22)
Worm Fecundity – Eosinophil	-0.05 (0.18)	-0.29 (0.06)	-0.69 (0.27)

Conclusion These results indicate that some (i.e. worm length and fecundity) but not all of the components of infection are moderate to highly heritable and that the indicator traits are also highly heritable. The indicator traits were moderately genetically correlated with the parasitological traits indicating that they may be suitable for inclusion in a selection index for the improvement of parasite resistance.

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Genetic analysis of meat quality and carcass composition traits in Scottish Blackface sheep

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Introduction Selection objectives in sheep breeding are changing as the nature of the pressures upon the sheep industry change. Sheep breeders particularly need to address product quality traits, as these will determine consumer acceptance of lamb. Critical traits determining product quality are carcass composition and meat quality. New measurement technology, such as Computer Tomography (CT), offers the potential for more accurate measurement of carcass traits in the live animal and consequently improved genetic gains. On the other hand, meat quality traits pose particular problems for improvement, as measurement is generally restricted to the slaughtered animal. The present study was designed to investigate carcass composition (as measured by CT) and meat quality traits, determine the inheritance of these traits, relationships between them, and investigate the prediction of meat quality traits from CT measurements. At a later stage, these data will form the basis for QTL studies for carcass and meat quality traits.

Methods The population studied comprised lambs derived from LEAN (L) and FAT (F) lines of Blackface sheep, previously divergently selected for predicted carcass composition (Bishop, 1993). Genotypes of measured lambs were L or F in 2000, and Lx(LxF) or Fx(LxF) in 2001 and 2002. A total of 499 lambs, comprising 99, 199 and 201 lambs in 2000, 2001 and 2002, respectively, were CT scanned at 6 months of age. Near-equal numbers of males and females were scanned each year. CT measurements were the areas and densities of fat, muscle and bone at the ischium (ISC), the 5th lumbar vertebrae (LV5) and the 8th thoracic vertebrae (TV8). Meat quality measurements were performed on 248 slaughtered male lambs (50 in 2000 and 99 in each of 2001 and 2002) on which carcass composition measurements were previously obtained. Meat quality measurements included initial and ultimate pH, colour of meat, conformation score and fat class, hot and cold carcass weight, instrumental texture and taste panel assessment of the cooked meat. The data were initially analysed using Residual Maximum Likelihood (REML), fitting effects of year, line, sex, litter size, dam age and, where appropriate, slaughter day, with sire fitted as a random effect. The overall line effect (F-L) was constructed from the backcross and pure line means. Multiple regression analyses were used to develop models for the prediction of meat quality traits using CT measurements, after pre-correcting all measurements for fixed effects. Finally, heritabilities were estimated using ASREML, fitting an animal model with all known ancestors (4847 animals).

Results There were significant F-L line differences ($p<0.05$) for predicted fat areas (ISC, LV5, TV8) scaled by live weight and also for bone density (TV8). Furthermore, significant F-L line differences ($p<0.05$) were observed for some meat quality traits (significant effects shown in Table 1). Heritabilities (with s.e.) for a selection of traits are shown in Table 2. For the CT measured fat areas, heritabilities were high, but they were lower for meat quality traits, where the highest heritabilities were for estimated subcutaneous fat proportion, colour a* and shear texture. Finally, colour a* was predicted from muscle densities with moderate accuracy (Table 3). Juiciness, carcass fat class and ultimate pH were also predicted from CT measurements with a reasonable degree of accuracy.

Table 1 Significant ($p<0.05$) F-L line differences

Trait	F-L line difference	s.e
Average fat area† (mm^2/kg)	12.05	4.49
Fat area ISC† (mm^2/kg)	9.15	4.31
Fat area LV5† (mm^2/kg)	7.84	3.71
Fat area TV8† (mm^2/kg)	15.0	6.77
Bone density TV8	6.30	3.03
Fat classification (score)	0.34	0.14
pH ultimate	-0.08	0.03
Reflectance L* (0=black)	1.42	0.38
Hue (0^0=red, 90^0=yellow)	1.58	0.41

†Fat areas scaled by live weight

Table 2 Heritabilities for CT and meat quality traits

Trait	h^2	s.e.
Fat area ISC	0.49	0.16
Fat area LV5	0.59	0.27
Fat area TV8	0.54	0.20
Colour a*	0.22	0.18
Colour b*	0.11	0.14
Reflectance L*	0.11	0.14
Subcutaneous fat prop^n	0.28	0.12
Fat classification	0.11	0.12
pH (at 45 minutes)	0.12	0.14
pH ultimate	0.11	0.15
Shear Texture	0.19	0.18

Table 3 Predictions of meat quality traits from CT measures

Trait	Predictor	% Variance explained
Colour a*	Muscle densities: TV8, ISC, LV5	50.0
Juiciness	Muscle density TV8, Fat area LV5	34.0
Fat Class	Muscle densities: LV5, ISC, TV8	23.0
Ultimate pH	Muscle densities: TV8, ISC, Fat area LV5	17.2

Conclusion Carcass traits as estimated by CT measurements on the live animal are highly heritable. Although heritabilities were generally lower for meat quality traits, the line differences suggest that altering carcass traits may alter some aspects of meat quality. Lastly, meat colour a* and juiciness can be reasonably accurately predicted from *in vivo* measurements on the carcass. Together, these results suggest that genetic improvement of sheep meat quality may be feasible.

Acknowledgements Defra are thanked for funding.improvement of sheep meat quality may be feasible.

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Effect of crossing Blackface ewes with five sire genotypes on lamb carcass characteristics

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Introduction Sire breed has been shown to have a major effect on growth rate, carcass characteristics and meat quality of lambs from hill sheep systems (Carson *et al* 2001). A research programme has been initiated in Northern Ireland to improve the genetic potential of the hill flock through crossbreeding, with the crossbred females being retained on the hill and used as replacement breeding females. However, as information is also required on the performance of the crossbred male lambs, the first objective of the current study is to assess the effect of crossbred lamb genotype on carcass characteristics. Lamb meat is high in fat and low in polyunsaturated fatty acids. Vegetable oil-based diets have been shown to influence the fatty acid composition of meat (Solomon *et al*, 1991). Therefore the second objective of the current study is to evaluate the effect of offering diets containing oilseed rape on lamb meat quality.

Material and methods A total of 278 lambs, produced by crossing Blackface ewes with Blackface, Swaledale, Cheviot, Lleyn or Texel rams (6 rams of each breed), were sourced from six hill farms located throughout Northern Ireland. The lambs were transferred to ARINI after weaning and allocated on the basis of genotype, live weight gain from birth to weaning and farm of origin to three finishing diets. The diets were grass nuts (0.90 *ad libitum),* soya (Hi Pro 50)-based concentrate diet (*ad libitum*) and oilseed rape-based concentrate diet (*ad libitum).* The concentrate diets were offered with grass nuts in a ratio of 80% concentrates to 20% grassnuts on a dry matter (DM) basis. Lambs were weighed weekly throughout the study and slaughtered at 42 or 50 kg. Group intakes were recorded daily. At slaughter, cold carcass weight, dressing proportion, conformation and fat classification were measured. Ultimate pH_U, Warner Bratzler Shear Force and CIELAB colour parameters (Carson *et al* 2001) were determined on loin chops taken at 24 hours post-mortem - The data were analysed by the Genstat REML (Residual Maximum Likelihood) procedure which fitted fixed effects for farm of origin, finishing diet and lamb genotype.

Results Swaledale-sired lambs had lower live weight gains compared to Lleyn-($P<0.01$), Cheviot-and Texel-($P<0.001$) sired lambs. Texel-sired lambs were on average 1.3 kg cold carcass weight heavier than the other crossbred lambs ($P<0.05$) with a greater proportion of U and R grades compared with Blackface- ($P<0.01$), Swaledale- ($P<0.001$) and Cheviot-sired lambs ($P<0.01$). Lambs offered diets containing a high proportion of concentrate had greater live weights gains (on average 62 g/d) ($P<0.001$), were 1.3 kg carcass weight heavier ($P<0.01$) and twice as many lambs obtained U and R grades ($P<0.001$) compared with those offered grass nuts. Meat pH and Warner Bratzler Shear force were unaffected by lamb genotype or finishing diet, although Swaledale-sired lambs had lower b* values compared with Texel-sired lambs ($P<0.05$) and lambs finished on the soyabean-based diet had higher values for a* and Chroma compared with those finished on the oilseed rape-based diet $P<0.05$).

Table 1 The effect of lamb sire genotype and finishing diet on carcass characteristics (results adjusted to fat class 3)

Lamb sire genotype	*Live weight gain (g/d)†*	*Dry matter intake (kg/d)*	*Cold carcass weight (kg)*	*Dressing proportion*	*Proportion U & R grades*	*a**	*b**	*Chroma*
Blackface	195^{ab}	1.24^{ab}	19.9^{a}	430	50^{b}	14.6	11.0^{ab}	18.3
Swaledale	174^{a}	1.20^{a}	20.2^{a}	434	27^{a}	13.9	10.3^{a}	17.3
Cheviot	248^{c}	1.41^{b}	20.3^{a}	420	45^{ab}	12.9	10.9^{ab}	16.9
Lleyn	211^{b}	1.33^{ab}	20.1^{a}	432	62^{bc}	13.2	10.7^{ab}	17.1
Texel	248^{c}	1.36^{b}	21.5^{b}	447	78^{c}	14.2	12.2^{b}	18.8
Sem	9.3	0.045	0.39	7.3	7.0	0.66	0.62	0.84
Significance	***	**	*	NS	***	P=0.07	*	NS
Diet								
Grass nuts	174^{a}	1.27	19.5^{a}	413^{a}	32^{a}	13.4^{ab}	10.6	17.2^{ab}
Soyabean	243^{b}	1.35	20.9^{b}	443^{b}	64^{b}	14.7^{b}	11.9	19.0^{b}
Oilseed rape	228^{b}	1.31	20.7^{b}	442^{b}	61^{b}	13.2^{a}	10.6	16.9^{a}
Sem	7.6	0.035	0.32	5.9	5.7	0.53	0.50	0.68
significance	***	NS	**	***	**	*	P=0.10	*

† live weight gain from start of study to slaughter a* relative redness, b* relative yellowness, Chroma = $(a^{*2}+b^{*2})^{0.5}$

Conclusions Choice of crossing sire in the hill flock had a significant effect on lamb growth and carcass characteristics but smaller effects on meat quality. High concentrate-based diets led to major increases in lamb growth rate and the proportion of lambs attaining higher-grade carcasses, with soyabean-based diets producing redder meat relative to oilseed rape-based diets.

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Effects of the murine myostatin allele *Mstn*$^{cmpt\text{-}dl1abc}$ on the segregation ratio in a high growth background – model experiment with mice

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Introduction Myostatin acts as a negative regulator of muscle growth. Mice and cattle deficient for myostatin have a dramatic increase in skeletal muscle mass (McPherron *et al*., 1997, Arnold *et al.*, 2001). Natural mutations in the *myostatin* gene have been seen in several cattle breeds and in one mouse line and in cattle the associated phenotype is referred to as 'Double-muscling' (DM). Although the direct DM effect seems to be positive in meat producing livestock with increased muscle and decreased fat there are reports of negative side effects in reproductive and other traits in cattle, with an indication of substantial interaction with the genetic background (Wiener *et al*., 2002). Thus it may be possible to select for the beneficial traits, while minimising the impact of the negative effects. Although negative side effects are not fully understood, breeding companies in the meat-producing sector are devoting considerable effort to high-throughput screening for mutations in this gene, hoping to find variants associated with increased muscularity. It is important that the impacts of such mutations on a wide range of production and welfare traits are fully explored before it becomes a focus of selection in meat producing livestock. The objectives of the work presented here were to utilise marker assisted introgression of a myostatin-deficiency producing partially recessive allele (*Compact*, *Mstn*$^{Cmpt\text{-}dl1Abc}$) to estimate its effects on traits of growth and fitness on the genetic background of an extreme high growth line, as a model of a highly developed livestock breed. Fitness effects as assessed by the segregation ratio are reported here.

Methods Two mouse lines were used: the Berlin High inbred line (BEHi), homozygous for *Mstn*$^{cmpt\text{-}dl1abc}$ (Varga *et al*., 2003), and a long-term growth selected and inbred mouse line (DUHi) (Bünger *et al*., 2001). *Mstn*$^{Cmpt\text{-}dl1Abc}$ (denoted *C*) was introgressed into DUHi by 6 generations of recurrent marker assisted backcrossing. Heterozygous animals of this line (denoted DUHi^{C}) were mated *inter se* in generations (gen) 5 to 10 to give homozygous wild-type (+/+), heterozygous (*C*/+) and homozygous *C*/*C* animals for *Mstn*$^{Cmpt\text{-}dl1Abc}$.

Results In gen 3 to 6 the 26 backcross matings produced a total of 257 genotyped offspring (Table 1), of which 45.5% were *C*/+ and 54.5% were +/+; the deviation from the expected 1:1 ratio was not significant, however (χ_C^2 = 2.06, χ_T^2 = 3.84). The *inter se* matings up to generation 10 produced a total of 838 genotyped pups, 29% +/+, 63.0% +/*C*, and only 7.9% (66 animals) *C*/*C*. This is a highly significant distortion of the segregation ratio (χ_C^2 = 132, χ_T^2 = 5.99), and the deviations from the expected 1:2:1 ratio were significant in all but one generation (gen 5). The relative frequencies of *C*/+ and +/+, 68.4% and 31.6%, did not depart from the expected 2:1 ratio (χ_C^2 = 1.04, χ_T^2 = 3.84). This indicates reduced viability only of *C*/*C* homozygotes. Nevertheless there were only negligible differences in litter size at birth and weaning between DUHi and DUHi^{C}.

Table 1 Offspring numbers from backcross matings (left) and *inter se* matings (right)

gen	*C*/+	+/+	all	χ_C^2	gen	+/+	*C*/+	*C*/*C*	all	χ_C^2
3	19	23	42	0.38	4	21	40	6	67	9.2
4	31	34	65	0.13	5	12	33	6	51	5.8
5	45	54	99	0.82	6	56	150	17	223	40.2
6	22	29	51	0.96	7	66	112	6	184	47.8
3-6	117	140	257	2.06	8	36	104	19	159	18.7
3-6 (%)	45.5	54.5	100		9	25	45	5	75	13.7
					10	28	44	7	79	12.2
					4-10	244	528	66	838	132.3
					4-10(%)	29.1	63.0	7.9	100.0	

Conclusions In a large F2 population from crosses of *Mstn*$^{cmpt\text{-}dl1abc}$/ *Mstn*$^{cmpt\text{-}dl1abc}$ animals of the Berlin High strain and inbred CAST/Ei founders, genotype frequencies agreed well with the expected 1:2:1 ratio (Varga *et al*., 2003). Therefore the deleterious effect on zygote formation or early survival of homozygotes found in the present study seems to result from a mutation by background interaction and needs further investigation.

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Differences in fat distribution between Scottish Blackface and Texel lambs

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Introduction Factors such as breed, sex, stage of maturity, stage of reproduction and nutrition are known to affect the amount and distribution of fat in different body depots of sheep. Between-breed differences may occur in fat distribution between different body regions, or between different depots (e.g. carcass / internal fat). For example, breeds selected for milking or maternal traits tend to deposit relatively large proportions of internal fat, whilst meat breeds deposit more carcass fat (Wood et al., 1980; Thompson and Ball, 1997). The aim of this study was to compare levels of fat in different body depots between Scottish Blackface and Texel lambs at finishing.

Materials and methods Thirty Scottish Blackface (SBF) and thirty Texel (T) entire male lambs were grazed as a single flock at SAC from weaning to 'finishing' (defined as the commercial slaughter point, based on condition score and live weight). Lambs reached finishing point in two mixed-breed batches (average ages of 199d and 161d in batch 1, and 212d and 166d in batch 2, for T and SBF lambs respectively) and were scanned using computerised tomography (CT) at this time. Cross-sectional CT reference scans were taken at three anatomical sites – 8th thoracic vertebra (TV8), 5th lumbar vertebra (LV5) and ischium (ISC) - representing the thoracic, lumbar and pelvic regions (Figure 1). Areas of total carcass fat (subcutaneous plus inter-muscular) in each scan (TV8ACF, LV5ACF and ISCACF respectively) were calculated for each lamb and used to predict total carcass fat weight, based on earlier derived breed-specific equations, and to calculate total proportion of fat in the carcass (FATPr). This work formed part of a larger study involving carcass and meat quality analyses, and one half of each batch (balanced for breed) was sent to the University of Bristol for slaughter a few days after scanning. The other half of each batch was sent 30 days later, after the sedative withdrawal period. Each carcass was given a fat class score (using the scale employed by the MLC), and kidney knob and channel fat (KKCF) was removed and weighed. Carcass fat class was converted to a numerical scale, equating to the expected subcutaneous fat percentage (MLCFAT; 1=4, 2=8, 3L=11, 3H=13, 4L=15, 4H=17, 5=20). Least-squares means were produced for the traits given in Table 1, using general linear regression (Genstat v.4.1; Lane and Payne, 1996). For each trait, fixed effects of batch and breed were fitted in the model. Fate (slaughtered after CT or 30d later) was also fitted as a fixed effect for KKCF. FATPr was fitted as a covariate for each trait.

Table 1 *Least-squares means (means in parenthesis FATPr not fitted in model)*

	Texel	Blackface	Sig. level
Age at CT scanning (d)	209 (206)	161 (163)	<0.001
Live weight at CT scanning (kg)	50.2 (48.7)	41.3 (42.8)	<0.001
TV8ACF(cm^2)	66.2 (56.1)	59.9 (70.1)	0.002
LV5ACF(cm^2)	25.3 (19.9)	22.6 (28.0)	0.012
ISCACF (cm^2)	50.1 (44.4)	51.3 (57.0)	0.544
KKCF (g)	305 (252)	309 (362)	0.872

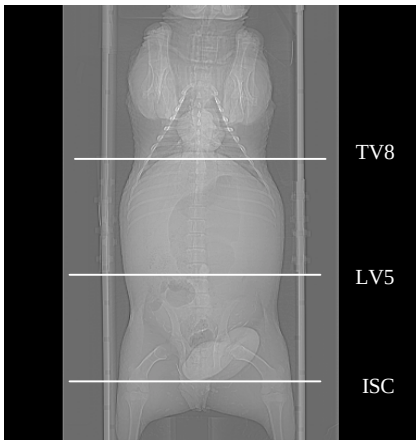

Fig 1 *CT reference scans*

Results Raw means, for T and SBF lambs respectively, were 0.20 and 0.24 for FATPr, and 7.43 and 10.5 for MLCFAT. At a given FATPr, SBF lambs were significantly younger and lighter than T lambs. CT fat areas, adjusted only for fixed effects, were significantly higher in SBF than T lambs in all three scans (25% to 40%), although SBF lambs were smaller. However, after correcting for FATPr, T lambs had significantly more fat in the thoracic (TV8, 9%) and lumbar (LV5, 11%) scans than SBF lambs, with no significant difference in pelvic fat (ISC) and KKCF (Table 1). As a percentage of total fat area in the 3 CT scans (sum), TV8ACF and LV5ACF were 1-2% higher in T than SBF lambs, whilst ISCACF was 3% higher in SBF lambs.

Conclusions Blackface lambs carry more carcass fat at finishing, and reach a given proportion of carcass fat younger and at lighter weights than Texel lambs. At the same overall proportion of carcass fat, Texel lambs have a greater absolute amount of fat in the scans taken in the thoracic and lumber regions than Blackface lambs, probably due to the larger size of the Texel lambs (as a correction for weight and overall fatness eliminates the significant breed difference). However, there are no breed differences in the absolute amount of fat in the pelvic scan, or in the kidney knob and channel, at a given proportion of carcass fat, despite the larger size of the Texel lambs. The results imply that Texel lambs carry a lower proportion of carcass fat in the pelvic region than Blackface lambs. These results also suggest that relative to live weight, Blackface lambs carry more kidney knob and channel fat than Texel lambs, at a given proportion of carcass fat. This agrees with the results of Wood et al. (1980), who found that maternal breeds have larger internal fat depots, which they suggested may be required to maintain lactation or as an energy reserve.

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Effect of feeding rumen protected conjugated linoleic acid on carcass characteristics and fatty acid composition of sheep tissues

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Introduction Recent research has focused on a component of ruminant fat, conjugated linoleic acids (CLA), which have been implicated with numerous health promoting properties including anti-carcinogenicity (Belury, 1995). Dietary supplementation with CLA has been shown to have a marked effect on tissue composition in several species, although there is apparently no evidence of such effects being seen in sheep (see Salter et al., 2002). Consequently, the aim of this study was to examine the effect of feeding growing lambs a CLA supplement, protected from rumen degradation, on carcass characteristics and tissue CLA content.

Materials and Methods Thirty-six Charollais x Mule ewe lambs approximately 10 weeks old (average initial liveweight 29.3 kg; no effect of treatment on starting liveweight $P > 0.05$) were fed three levels of rumen protected CLA (PCLA), containing similar levels of the two major CLA isomers (*cis*-9, *trans*-11 and *trans*-10, *cis*-12), or Megalac (MEG; Volac Ltd, U.K.) which was fed to control for energy content at each PCLA level. The CLA was protected by a lipid based coating which, in previous sheep studies, was shown to allow 65 % of the CLA to reach the duodenum. Megalac is a commercially available rumen protected fat ingredient composed of a combination of natural plant oil (palm fatty acids) and calcium. Animals were randomly allocated to one of 7 treatment groups which were fed to achieve a growth rate of 180 g/d.: basal diet (control; n = 6), and then basal diet plus 25 g PCLA/kg diet DM (LoPCLA; n = 5), 50 g PCLA/kg diet DM (MedPCLA; n = 5), 100 g PCLA/kg diet DM (HiPCLA; n = 5), 21.7 g MEG/kg diet DM (LoMEG; n = 5) 43.3 g MEG/kg diet DM (MedMEG; n = 5) and 86.6 g MEG/kg diet DM (HiMEG; n = 5). The trial was conducted over a 10-week period. At slaughter, samples of adipose tissue (perirenal, omental and subcutaneous), L. dorsi muscle and liver were taken and frozen at –40^{o}C. Various carcass parameters were also measured, as shown in Table 1. Lipid was extracted using a 2:1 chloroform:methanol solution. Prior to GC analysis using a 60m BPX70 column, adipose tissue was methylated by base methylation and muscle and liver samples by combined base-acid methylation. Data was analysed by ANOVA to determine the effects of Amount of fat x Type of fat.

Results In liver ($P < 0.001$) and all adipose tissue deposits studied ($P < 0.02$), there was an Amount of fat x Type of fat interaction for the levels of both *cis*-9, *trans*-11 and *trans*-10, *cis*-12 CLA; proportions of both CLA isomers increased with amount of PCLA fed but were not altered with increasing Megalac inclusion. For the L. dorsi muscle, although there were no significant effect on *cis*-9, *trans*-11 CLA content, a similar dose accumulation ($P < 0.001$) with increasing PCLA supplementation was seen for the *trans*-10, *cis*-12 isomer. Although the CLA had reach the animal's tissues, there were, however, no significant effects of feeding protected CLA supplement on any of the carcass composition parameters measured.

Table 1 Carcass characteristics and conjugated linoleic acid content of sheep tissues*

		Diet								
		Control	LoMEG	MedMEG	HiMEG	LoPCLA	MedPCLA	HiPCLA	P-value	SED
Carcass weight, kg		20.2	20.7	19.7	19.9	20.3	20.5	20.8	0.437	0.77
Backfat, mm		4.4	3.6	3.6	4.0	3.9	4.3	4.0	0.791	0.73
Omental weight, g		643.1	662.5	663.4	594.7	645.4	662.6	705.6	0.737	125.5
Perirenal weight, g		472.8	534.0	555.6	488.1	491.7	564.5	523.0	0.852	97.7
L.dorsi weight, g		615.5	612.7	556.0	602.7	595.2	589.6	646.2	0.421	35.3
Liver weight, g		663.5	677.8	674.3	629.3	617.4	616.3	652.1	0.366	46.4
Conjugated linoleic acid content, moles per 100 moles fatty acid methyl ester										
	Subcut	0.89	0.78	0.92	0.83	1.09	1.34	1.95	0.020	0.206
	Omental	0.67	0.71	0.80	0.73	0.95	1.23	1.77	<0.001	0.134
cis-9,trans-11	Perirenal	0.45	0.46	0.49	0.51	0.68	1.00	1.62	<0.001	0.101
	L.dorsi	1.01	0.92	1.13	0.99	1.15	1.30	1.30	0.159	0.145
	Liver	0.39	0.40	0.42	0.54	0.75	1.18	2.30	<0.001	0.104
	Subcut	0.04	0.02	0.10	0.08	0.18	0.38	0.76	<0.001	0.045
	Omental	0.05	0.07	0.08	0.10	0.19	0.36	0.75	<0.001	0.046
trans-10,cis-12	Perirenal	0.04	0.06	0.12	0.23	0.21	0.38	0.76	0.001	0.063
	L.dorsi	0.01	0.02	0.03	0.06	0.05	0.14	0.36	<0.001	0.033
	Liver	0.04	0.10	0.11	0.14	0.19	0.34	0.64	<0.001	0.051

* P-value and SED for the Amount of fat x Type of fat interaction

Conclusion Conjugated linoleic acid content increased with protected conjugated linoleic acid supplementation, but there was no evidence of a reduction in adipose tissue or an increase in muscle mass in sheep tissues.

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Effect of age on the fatty acid classes of beef muscle

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Introduction Ruminant products are considered as a major source of saturated fatty acids (SFA) in the human diet and a reduction in the intake of SFA along with a concomitant increase in the intake of *n*-3 series PUFA is recommended by nutritionists (Department of Health, 1994). The major fatty acid classes in beef are the saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) and beef is a nutritionally important source of the beneficial *n*-3 series PUFA. Experiments investigating the effects of age on lipid composition in beef muscle have, in the main, used short time periods and also been subject to confounding effects of differences in growth rate (Rule *et al.*, 1997). This study is part of a larger investigation into the effects of breed and diet, as well as age, on muscle lipids (Warren *et al.*, 2003). This paper will focus on the effect of age.

Materials and Methods Forty eight Aberdeen Angus (AA) and 48 Holstein-Friesian (HF) steers (initial age 6 months and live weight ~200kg) were allocated to one of six treatments based on a forage or concentrate diet and slaughtering at 14, 19 or 24 months of age, resulting in eight animals per breed per treatment. The diets were either *ad libitum* grass silage plus sugarbeet pulp shreds at *circa* 0.15 of the total dry matter (DM) intake or a barley-based, full-fat soya concentrate and chopped barley straw fed at a ratio of 70:30 on a DM basis. Animals were weighed every 14 days, the intake of the concentrate fed animals was adjusted in order to maintain similar growth rates (~900g/d) between diets within breed (see Warren *et al.* 2003) for further details. Fatty acid analysis in *m.longissimus* was conducted using gas chromatography (GC) and proportions of SFA, MUFA and PUFA, as well as PUFA:SFA (P:S) and *n*-6:*n*-3 ratios were calculated for total lipid. SFA were C14:0, C16:0 and C18:0. MUFA consisted of C16:1, C18:1 *trans*-11, C18:1 *cis*-9, C18:1 *cis*-11 and the PUFA consisted of C18:2*n*-6, C18:3*n*-3, C18:2 *cis*-9, *trans*-11 and the long-chain PUFA C20-22. The data were analysed by general analysis of variance with slaughter age, breed and diet as the main factors. Since the diet x age interaction was significant, the age effects are reported for each diet.

Results Total lipid content of muscle increased with increasing age. The proportion of SFA tended to increase between 14 and 19 months of age. The proportions of MUFA and PUFA increased and declined, respectively, with PUFA declining by *circa* 0.5 with increasing slaughter age. This is reflected in the results for the P:S ratio which declined throughout but was higher with the concentrate diet. The *n*-6:*n*-3 ratio was very high on the concentrate diet (> 8) and increased with age. In comparison the *n*-6:*n*-3 ratio was low (<2) on the grass silage and not influenced by age.

	14		19		24			sig.		
	Conc	Silage	Conc	Silage	Conc	Silage	s.e.d.	A	D	AxD
	mg/100g muscle									
Total lipid	1724	2632	3048	5126	5069	7152	725.4	***	***	NS
	proportions									
SFA	40.1	42.3	41.4	43.1	40.9	42.4	0.72	NS	***	NS
MUFA	36.5	41.3	39.7	44.7	44.3	45.6	0.81	***	***	**
PUFA	13.0	6.6	9.6	3.7	5.9	3.8	0.76	***	***	***
P:S	0.33	0.13	0.26	0.08	0.16	0.09	0.018	***	***	***
n-6:*n*-3	8.9	1.2	14.4	1.1	14.3	2.0	0.88	***	***	***

NS, not significant; *, P<0.05; **, P<0.01; ***, P<0.001. A, age; D, diet.

Conclusions Increasing animal age resulted in increasing intramuscular (marbling) fat deposition, especially on the grass silage diet. This was associated with an increase in the proportion of MUFA but a decline in PUFA, in both diets. This partly reflects a decline in the proportion of the membrane phospholipids which contain a high proportion of PUFA, especially C18:2*n*-6 and the longer chain C_{20} PUFA.

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Effects of breed, diet and age on shelf life, muscle vitamin E and eating quality of beef

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Introduction. Fatty acid composition and vitamin E content of beef are affected by breed, diet and age, with implications for meat quality. The effects on shelf life and flavour were investigated in this project.

Materials and methods 96 steers were used in the trial, half Aberdeen Angus cross (AA) and half Holstein-Friesian (HF). From 6 months of age they were fed, proportionately, either perennial ryegrass silage (containing 0.15 sugar beet pulp) or concentrates (0.6 barley, 0.2 sugar beet pulp, 0.125 full fat soya) containing 12 mg per kg vitamin E. They were reared to 14, 19 or 24 months of age. An additional 8 steers of each breed were reared to 14 months on grass silage and from 14 to 19 months they were grazed on perennial ryegrass pasture. After slaughter, a loin joint was removed and aged in vacuum pack for 10 days at 1ºC. Steaks were cut and displayed in modified atmosphere packs for 12 days under retail conditions and colour was measured daily. Lipid oxidation, an index of freshness, was measured at 4 and 7 days as thiobarbituric acid reacting substances (TBARS). Vitamin E in fresh loin muscle was measured by HPLC. Loin joints were frozen before taste panel analysis. Steaks were grilled to an internal temperature of 75ºC and assessed by the trained taste panel. Results were analysed by Anovar with diet and/or age as co-variates

Results Breed had few effects and so results for the two breeds have been combined. Silage-fed animals had more vitamin E and lower lipid oxidation (TBARS) than concentrate-fed animals ($P<0.05$) (Figure 1) at all three ages. At 19 months, fresh grass produced higher vitamin E than did grass silage. Colour was retained better in steaks from grass silage-fed cattle as shown by the slower decline in saturation (Figure 2) (similar results at 19 and 24 months). The grass silage diet elicited higher scores for "livery" and at 19 months, beef flavour was higher and abnormal flavour lower in the grass silage and pasture fed groups, which were similar (Table 1).

Figure 1. The effect of age and diet upon TBARS (mg malalonaldehyde/kg±sd) and vitamin E (mg/kg±sd) in loin muscle

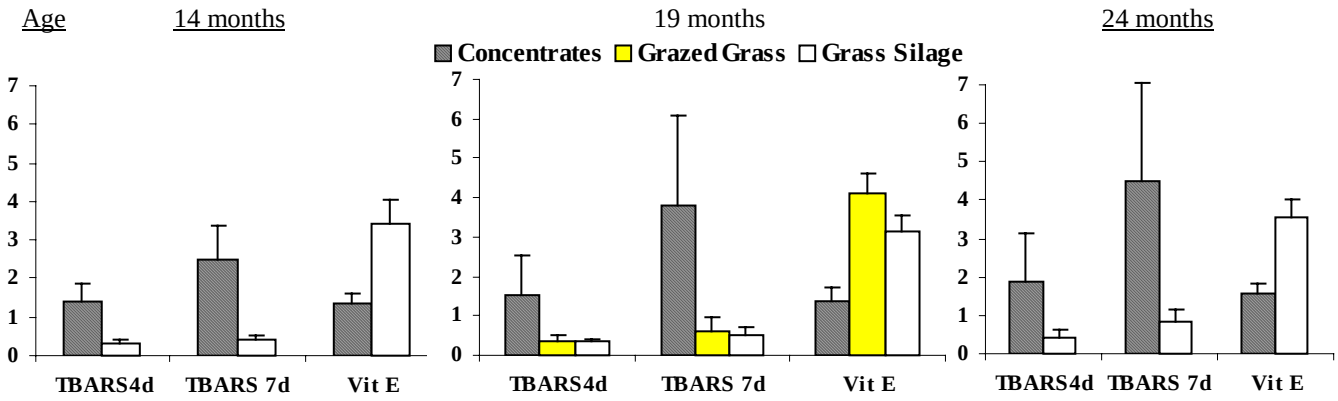

Figure 2. Effect of diet and days displayed on colour saturation (±sem) of loin steaks in MAP

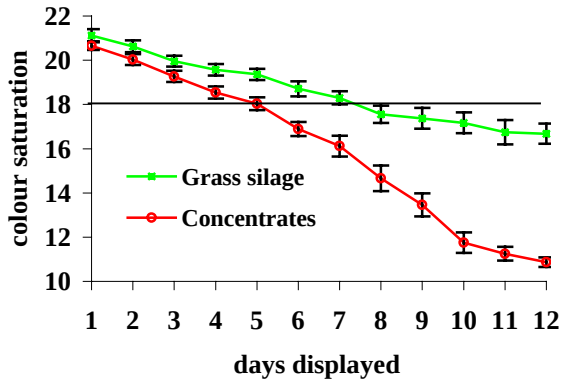

Table 1 Effects of diet on eating quality of grilled sirloin steaks (1-100 scales)

	Grass silage	Pasture	Concs	sed	sig
14 months					
Beef flavour	30	-	30	1.3	NS
Abn. Flavour	13	-	12	1.2	NS
Livery	14	-	10	1.3	**
19 months					
Beef flavour	28	26	23	1.3	**
Abn flavour	11	13	19	1.4	***
Livery	9	9	7	1.3	NS
24 months					
Beef flavour	30	-	28	1.3	NS
Abn flavour	14	-	16	1.2	NS
Livery	16	-	10	1.6	***

Conclusions Grass diets produce better shelf life characteristics than concentrates and eating quality is improved.

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Effect of including a ruminally protected lipid supplement in the diet of bulls on fatty acids and other aspects of meat quality

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Introduction Under controlled experimental conditions, ruminally protected lipid supplements (PLS) rich in 18:2n-6 and 18:3n-3 have been successful in creating large shifts in the fatty acid composition of beef muscle (Scollan *et al.,* 2003). However, there is a need to test methodology under commercial conditions and with a wider range of breed types. This study was conducted at a Yorkshire Farm and used Charolais Cross and the Stabiliser breed, a mix of 5 breeds designed to combine efficient production and good carcass quality.

Materials and methods Fifteen Charolais and fifteen Stabiliser bulls (initial age and liveweight 10months and 320kg, respectively) were allocated to one of three dietary treatments (normal commercial concentrate, control (C); control plus 0.5kg/d of protected lipid supplement, PLS1; control plus 1kg/d of protected lipid supplement, PLS2), resulting in five animals per type per treatment. The PLS comprised of soyabean, linseed and sunflower oils and was formulated to achieve an 18:2*n*-6:18:3*n*-3 ratio of 1:1. Animals were fed for *circa* 80d at JSR Farms, Driffield, Yorkshire, then transported to St Merryn, Merthyr Tydfil for slaughter. Deboned siroin was conditioned in vacuum bags for 10d and then lipid oxidation and colour (L*a*b*) shelf-life were measured after 7d of simulated retail display in modified atmosphere (MAP) (4°C, 700 lux for 18h out of 24h). Fatty acids (GC) were analysed from samples of *Longissimus dorsi* removed 48h post-mortem. The data were analysed using a general analysis of variance with type and diet as the main factors.

Results Half carcass weight and conformation score was not different between treatments. The Stabiliser bulls had higher fat cover compared with the Charolais. Total muscle FA decreased with the addition of 500g/d PLS. However, those animals receiving PLS 2 had a higher level of total muscle FA compared with both the C and PLS 1 animals. Levels of both 18:2*n*-6 and 18:3*n*-3 increased with increasing amount of PLS in the diet. In general, all the PUFA, CLA and the proportion of SFA (saturated FA) followed the same trend as the total FA. The proportions of MUFA (monounsaturated FA) and PUFA decreased and increased, respectively, with increasing levels of PLS, the greatest change occurring between C and PLS1. This is reflected in the increasing P:S ratio with increasing PLS supplementation. The *n*-6:*n*-3 ratio increased with the addition of the PLS. All FA tended to be influenced by breed, as well as diet. Lipid oxidation was higher and colour saturation lower (meat browner) in animals given the PLS.

Table 1 Effect of different levels of PLS on carcass characteristics and meat quality of bull beef

	Charolais			Stabilisers				Significance		
	C	PLS1	PLS2	C	PLS1	PLS2	s.e.d.	B	D	BxD
Carcass weight (kg)	174.5	179.7	178.3	173.1	161.2	173.9	7.76	NS	NS	NS
Conformation (1-155)	108.0	114..0	130.0	115.0	102.0	114.0	13.07	NS	NS	NS
Fat class (1-145)	93.0	80.0	78.0	96.0	97.0	99.0	8.30	**	NS	NS
				Fatty acids (mg/100g muscle)						
Total fatty acids	2109	1559	2162	2880	2421	4242	353.1	***	**	*
18:2*n*-6	83.0	118.5	148.1	98.3	119.0	174.8	9.53	*	***	NS
18:3*n*-3	4.9	18.5	20.2	6.2	20.6	31.8	1.94	***	***	***
CLA (*cis* 9, *trans* 11)	9.7	6.3	8.6	14.6	11.0	16.9	1.81	***	**	NS
20:4*n*-6	24.3	19.9	23.5	29.9	22.5	29.5	1.72	***	***	NS
20:5*n*-3	8.7	8.8	9.2	10.4	8.0	12.1	1.02	*	*	*
22:5*n*-3	11.1	10.8	11.6	14.8	10.7	15.1	0.94	***	***	**
22:6*n*-3	1.2	0.8	0.9	1.3	0.7	0.8	0.11	NS	***	NS
Proportion SFA	0.47	0.44	0.45	0.46	0.45	0.47	0.87	*	**	NS
Proportion MUFA	0.43	0.38	0.37	0.44	0.41	0.40	1.10	***	***	NS
Proportion PUFA	0.92	0.17	0.17	0.85	0.13	0.12	1.29	***	***	*
P:S	0.13	0.33	0.28	0.12	0.22	0.18	0.040	**	***	NS
n-6:*n*-3	2.3	2.4	2.7	2.1	2.4	2.4	0.08	**	***	NS
Lipid oxidation[1] (d7)	2.1	4.5	5.6	2.3	5.1	7.0	1.19	NS	***	NS
Colour saturation (d7)	17.1	14.5	13.9	17.6	14.1	11.6	1.88	NS	**	NS

NS, not significant; ***; P<0.001; **, P<0.01; *, P<0.05; [1]mg malonaldehyde/kg meat; B, Breed; D, diet

Conclusions The addition of a PLS rich in PUFA increased deposition of these FA in the animal tissue. This was reflected in a beneficial shift in P:S value while the *n*-6:*n*-3 ratio remained at a low level. It is unclear why levels of total and certain FA increased following addition of PLS 2. The Stabiliser bulls had more fat and incorporated more dietary PUFA. The results for lipid oxidation and colour are indicative of the increased deposition of PUFA and insufficient antioxidant levels in the diet.

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The effects of fish oil inclusion in the concentrate and method of silage preservation on fatty acid composition of muscle from steers

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Introduction Fat of ruminant origin is one of the main dietary sources of conjugated linoleic acid (CLA), considered to have several human health promoting properties. Production of CLA occurs during ruminal biohydrogenation of dietary linoleic acid and by tissue desaturation of trans-vaccenic acid (TVA) produced during ruminal biohydrogenation of linoleic and linolenic acid. Wilting of grass prior to ensiling decreased the content of linolenic acid (Dewhurst et al., 1998), which may decrease CLA synthesis. Dietary inclusion of a source of long-chain polyunsaturated fatty acids (P), such as fish oil may limit the extent of biohydrogenation of shorter-chain P leading to an accumulation of CLA and TVA (Wonsil et al., 1994). The objective of this study was to determine the effect of inclusion of fish oil in the supplementary concentrate and wilting of grass prior to ensiling on the fatty acid composition of beef intramuscular adipose tissue .

Materials and methods Eighty Friesian steers (BW= 565 kg) were blocked on bodyweight and within block, randomly assigned to one of eight dietary treatments. Animals were offered either unwilted or wilted grass silage (S) and one of four concentrate rations: 0g fish oil (F)/kg (F0), 10g F/kg (F10), 20g F/kg (F20) or 40g F/kg (F40) in a 2×4 factorial arrangement. All rations were enriched with 80g sunflower oil/kg. Growth was monitored at three-week intervals to achieve similar carcass weights at the end of the 108-day experimental period. Animals were slaughtered in a commercial abbattoir and carcasses were chilled for 48h at 4ºC. Intramuscular fat was extracted in duplicate from samples of *M. longissimus dorsi*, separated into neutral and polar fractions using pre-packed SPE cartridges and then methylated. Fatty acid methyl esters (FAME) were analysed by gas-chromatography with a 100m CP-88 Sil column and the concentration of individual fatty acids in the muscle determined. Data were analysed according to a randomised block design using Genstat 6.0. The effect of increasing concentration of F in the concentrate was tested using orthogonal polynomials.

Results The fatty acid data are summarised in Table 1. In neutral lipids, increasing fish oil supplementation linearly increased the concentration of CLA (c9t11 isomer) and TVA and linearly decreased the n-6:n-3 ratio. In polar lipids, increasing fish oil supplementation linearly increased the concentration of EPA and DHA and linearly decreased the n-6:n-3 ratio. Wilting of grass prior to ensiling silage increased the concentration of CLA in the neutral lipids.

Table 1 Concentration of fatty acids in *M. longissimus dorsi*

	Unwilted silage				Wilted silage				s.e.d.	F	S	F×S
	F0	F10	F20	F40	F0	F10	F20	F40				
Neutral lipids (mg/100g muscle)												
C 18:2	99.41	68.80	82.91	91.40	103.8	88.83	92.65	76.70	11.30	*	n.s.	n.s.
C 18:3	25.50	17.92	20.84	27.81	27.82	24.46	23.67	21.05	3.138	n.s	n.s	*L
CLAc9t11	50.55	38.04	48.49	72.19	60.43	64.96	63.44	67.87	8.624	**L	**	0.09
TVA	374.4	277.7	347.3	472.4	375.6	404.5	422.8	457.8	51.23	**L	0.07	n.s
ω-6:ω-3 Ratio	3.78	3.98	3.80	3.41	3.63	3.42	3.70	3.49	0.182	*L	0.05	n.s
Total FA	6281	4802	5761	7562	6843	6893	6477	6102	809.6	n.s	n.s	*L
Polar lipids (mg/100g muscle)												
CLAc9t11	1.23	1.21	1.29	1.33	1.16	1.29	1.35	1.39	0.172	n.s.	n.s.	n.s.
TVA	4.04	3.68	3.90	4.80	3.07	3.82	3.76	4.00	0.581	n.s.	n.s.	n.s.
C 20:5n-3	3.27	4.02	4.29	4.79	2.60	3.86	3.56	5.15	0.723	***L	n.s	n.s.
C 22:6n-3	1.17	0.90	1.39	1.45	0.72	0.77	0.97	1.40	0.283	**L	0.07	n.s.
ω-6:ω-3 Ratio	3.99	3.69	3.58	2.71	3.78	3.49	3.59	2.74	0.277	**L	n.s.	n.s.
Total FA	240.1	243.2	247.8	240.7	234.3	238.5	235.8	228.2	8.902	n.s	n.s	n.s.

* = <0.05, ** = <0.01, *** = <0.001; L=Linear, Q= Quadratic

Conclusions Fish oil supplementation enhanced the concentration in beef, of fatty acids that are beneficial to human health. Wilting of grass prior to ensiling did not impact negatively on the overall content of n-3 P in muscle, but it increased the concentration of CLA.

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The effects of including ruminally protected lipid in the diet of Charolais steers on animal performance, carcass quality and the fatty acid composition of longissimus dorsi muscle

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Introduction Effective ruminal protection of dietary polyunsaturated fatty acids (PUFA) is very useful in helping to reduce microbial biohydrogenation of PUFA and results in major improvements in the ratio of polyunsaturated:saturated fatty acids (P:S) in beef muscle (Scollan *et al.*, 2003). However, in that study the protected lipid study (PLS) used which consisted of soya beans, linseed and sunflower oils mixed to give a 2.4:1 ratio of 18:2*n*-6:18:3*n*-3, was less successful in improving the *n*-6:*n*-3 ratio in beef muscle. This study reports the effects of including in the diet a PLS with a lower ratio of 18:2*n*-6:18:3*n*-3 on the fatty acid composition of the m. *longissimus.*

Materials and methods Thirty two Charolais steers (initial live weight 507 (s.e. 10.3) kg) were randomly allocated to one of four dietary treatments, each consisting of eight animals. The treatments were based on *ad libitum* grass silage plus one of four concentrates in which the lipid source was either Megalac (Mega, rich in palmitic acid; 16:0) or PLS (soya beans, linseed and sunflower oils resulting in a 1:1 ratio of 18:2 *n*-6:18:3 *n*-3): Concentrate 1, (Mega, control) contained 139g/kg Mega; Concentrate 2, (PLS1) contained 67g/kg Mega with 400 g/d PLS fed separately; Concentrate 3, (PLS2) contained 24g/kg Mega with 800 g/d PLS fed separately, Concentrate 4, (PLS3) contained no Mega and 1000 g/d PLS fed separately. The PLS was considered as part of the overall concentrate allocation per day in maintaining an overall forage:concentrate ratio of 60:40 on a DM basis. To ensure that total dietary oil and protein intake was balanced across the 4 treatment groups, the 4 concentrates differed in formulation and hence chemical composition. The crude protein (CP) and AHEE were 174, 155, 136 and 128 and 107, 83, 49 and 26 g/kg DM for Mega, PLS1, PLS2 and PLS4, respectively. The CP and AHEE of the protected lipid supplement were 3320 and 354 g/kg DM, respectively. Total dietary oil was formulated to be 0.065 of DM of which 0.05 was the test oil. Daily feed intakes and live weights were monitored. Animals were slaughtered after 90 days on treatment, carcasses were classified and samples of *longissimus dorsi* were acquired for fatty acid analysis. An ANOVA with diet as the main factor was used to analyse the animal performance, carcass and fatty acid results.

Results Total DM intake, liveweight gain, half carcass weight and fat score (0-100 scale) were similar across treatments and averaged 9.4 kg/d (s.e.d. 0.33), 1.3 kg/d (s.e.d 0.10), 183 kg (s.e.d. 3.6), 90.8 (s.e.d. 7.91), respectively. Total muscle fatty acids, the content of the main saturated FA (14:0, 16:0, 18:0) and 18:1*n*-9 were not different (Table 1). On average, feeding PLS increased the content of 18:2*n*-6 and 18:3*n*-3 by a factor of 2.3 and 4.2, respectively. There was a tendency for CLA to increase with inclusion of PLS. The content of 20:5 n-3 (EPA; synthesised from 18:3 n-3), was increased by the PLS ($P < 0.05$). The P:S and *n*-6:*n*-3 ratio was increased with inclusion of PLS ($P < 0.001$).

Table 1 Fatty acid content (mg/100g muscle) of m.longissimus dorsi

	Mega	**PLS1**	**PLS2**	**PLS3**	**s.e.d.**	**P**
14:0 myristic	126.3	125.2	121.7	116.5	23.41	NS
16:0 palmitic	1305	1311	1238	1175	205.2	NS
18:0 stearic	717	731	773	788	114.2	NS
18:1 *trans*	105.2	110.7	113.2	132.5	18.43	NS
18:1n-9 oleic	1645	1669	1610	1612	275.9	NS
18:1 cis vaccenic	68.1	68.8	65.9	66.9	10.11	NS
18:2 n-6 linoleic	120.4	255.2	279.0	305.1	23.36	0.001
18:3 n-3 α-linolenic	28.6	101.7	117.9	138.9	13.08	0.001
CLA cis-9, trans-11 C18:2	19.9	24.2	24.1	31.0	4.29	NS
20:4 n-6 arachidonic	27.4	28.9	25.2	25.5	2.00	NS
20:5 n-3 eicosapentaenoic (EPA)	12.6	14.9	13.8	16.1	1.13	0.05
22:5 n-3 docosapentaenoic (DPA)	22.7	23.5	19.5	19.5	1.66	0.05
22:6 n-3 docosahexaenoic (DHA)	1.89	1.80	1.53	1.56	0.272	NS
Total fatty acids	4685	4976	4880	4895	737	NS
n-6:*n*-3 ratio	2.27	2.02	2.00	1.88	0.055	0.001
P:S ratio	0.07	0.177	0.199	0.218	0.0179	0.001

Conclusions The protected lipid supplement rich in 18:2*n*-6 and 18:3*n*-3 resulted in large increases in these fatty acids in beef muscle. This resulted in a favourable increase in the P:S ratio and beneficially a lower *n*-6:*n*-3 than that observed in our previous study (Scollan *et al*., 2003).

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Temporal effects of protein supply on local immunity to nematodes in periparturient ewes

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Introduction There is an increasing body of evidence to support the view that the periparturient breakdown of immunity to parasites has a nutritional basis (Houdijk et al., 2003). Nutritional improvement of expression of immunity to parasites has been assessed indirectly through changes in faecal egg counts (FEC) and worm burden. A direct assessment of effector responses is hampered by its local nature and would be limited to analysing gut tissue samples obtained at slaughter. However, recently an abomasal cannulation methodology was developed that allows for serial sampling of the abomasal mucosa throughout the periparturient period in sheep (Huntley et al., in press). Here, this methodology was used to assess temporal effects of metabolizable protein (MP) supply to parasitized, periparturient sheep on abomasal inflammatory cells that are associated with expression of immunity to nematodes.

Materials and methods Twelve twin-bearing ewes were trickle infected with *Teladorsagia circumcincta* (10,000 infective larvae per day, three days per week) from day$_{-47}$, relative to expected parturition, onwards. The daily allowance of hay and pelleted concentrates was calculated to provide either 0.8 (L) or 1.3 (H) times MP requirements during the periparturient period, whilst all allowances were calculated to provide 0.9 times the metabolizable energy requirement. Ewes were fitted with an abomasal cannula on day$_{-63}$, through which mucosal tissue biopsies were taken up to twice weekly from day$_{-28}$ onwards. The biopsies were assessed for mucosal mast cells (MMC), globule leukocytes (GL) and eosinophils (EOS) counts. Ewes and lambs were weighed up to twice weekly, FEC (eggs per gram faeces, epg) were taken twice weekly from day$_{-37}$ onwards, and worm burdens were assessed at day$_{42}$. Worm burdens, FEC, and cell counts were log-transformed; the latter two were analyzed via repeated measures ANOVA. Transformed data are reported as backtransformed means with 95% confidence intervals.

Results The L and H ewes weighed 65.7 and 74.7 kg, respectively (s.e.d. 3.11; P<0.05) post parturition, and their litters weighed 8.9 and 10.8 kg, respectively (s.e.d. 0.96; P=0.12). MP supply did not affect body weight loss during lactation, which averaged 257 g/day (s.e. 43), but milk production of the L and H ewes (calculated from lamb body weight and weight gain) averaged 3.0 and 4.1 kg/day, respectively (s.e.d 0.33; P<0.05). Figure 1 shows the FEC, MMC and GL counts. The H ewes had lower FEC than the L ewes during lactation (P<0.01). MMC counts were temporarily reduced but were not affected by MP supply. However, compared to the L ewes, the H ewes had temporarily elevated GL counts (P<0.05; Fig 1). MP supply did not affect EOS counts, averaging at 22 (16-31) cells/mm^2. The worm burdens of the L and H ewes averaged 18100 (12100-27000) and 7000 (5600-8800), respectively (P<0.05).

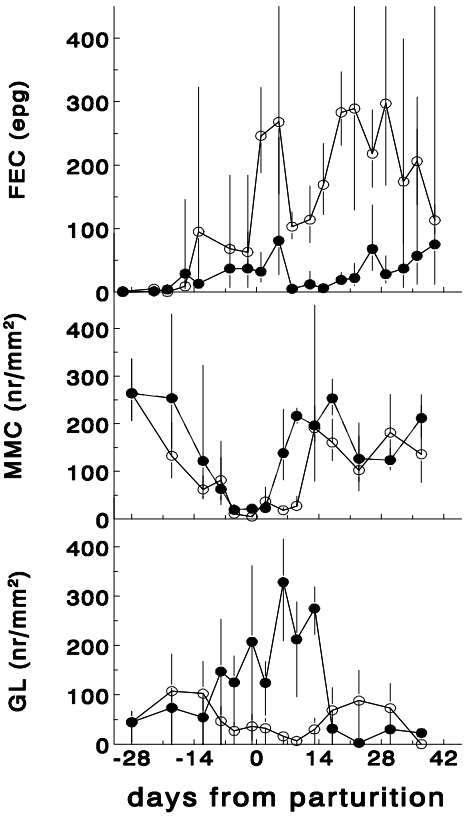

Figure 1. Faecal egg counts (FEC), mucosal mast cells (MMC) and globule leukocytes (GL) of parasitized, twin-rearing ewes, fed at 0.8 (○) or 1.3 (●) times their MP requirements

Conclusion The results of this study suggest that the nutritionally improved expression of immunity to abomasal nematodes in periparturient ewes may be associated with temporarily elevated abomasal globule leukocyte counts. Overall, the study supports the view that improved protein supply could improve expression of immunity to abomasal nematodes in periparturient ewes, and thus reduce our dependency on anthelmintic drugs for parasite control.

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Effect of post-mating nutrition on lamb output, foetal development and post-natal lamb performance in mature and adolescent ewes

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Introduction Nutrition of the ewe during early pregnancy has important implications for lamb output through its effects on implantation and early embryonic development. In adolescent ewes a high plane of nutrition during the first half of gestation has been found to reduce conception rate, lamb birth weight and neonatal lamb survival (Wallace *et al*., 1996). However few studies have examined the effects of nutrition immediately post-mating on foetal development and subsequent lamb performance. The current experiment was set up to investigate how plane of nutrition of adolescent and mature ewes during the first month after mating affects lamb output, foetal development and lamb growth.

Materials and methods In a two year study, 102 Greyface and Texel x Greyface ewes (liveweight 76 s.d 6.3 kg; condition score 3.8 s.d 0.3) and 114 Texel x Greyface ewe lambs (liveweight 47 s.d 4.2 kg; condition score 3.3 s.d 0.3) were allocated to one of three treatments (n = 34 ewes and n = 38 lambs per treatment) in a 3 x 2 factorial design, balanced for liveweight, condition score, ewe breed and sire breed. All animals were oestrus synchronized and hand mated to Suffolk and Texel rams. Eighteen hours after mating, ewes were individually housed and placed on one of three nutritional regimes estimated to supply 2.0 (H), 1.0 (M) and 0.6 (L) of daily maintenance ME requirements (Agriculture and Food Research Council, 1993). Treatments were imposed from day 1-31 of pregnancy using grass nuts (10.7 MJ ME/kg DM; 172 g CP/kg DM; estimated 'a' = 0.37 [AFRC, 1993]) offered at three different levels. Feed intake was measured daily. Pregnancy was confirmed by ultrasound on day 33 and non-pregnant animals were removed from the study. From day 31-108 all animals were offered a fixed level of feeding to meet their estimated energy and protein requirements (AFRC, 1993). During the final 6 weeks of gestation the level of feeding was determined by foetal number and increased weekly until term. Liveweight and BCS were measured weekly during the treatment period and fortnightly thereafter until lambing. Lambs were weighed at birth and fortnightly thereafter until weaning. Lamb growth rate was determined by linear regression. Data were analysed in a 3 x 2 (nutrition x ewe parity) factorial design using REML analysis, including fixed effects for year of study, ewe breed, sire breed and litter size.

Results No significant treatment x ewe parity interactions were observed, therefore main effects only are presented (Table 1). Plane of nutrition during early pregnancy led to significant differences in liveweight and body condition score change (P<0.001) during the early pregnancy treatment period (H > M > L). A significant compensatory response was also observed in terms of liveweight (P<0.05) and body condition score (P<0.001) during mid pregnancy (L > M > H). Ewe lambs lost significantly (P<0.001) more liveweight than mature ewes during early pregnancy but maintained their condition score (P<0.001) during both early and mid-pregnancy periods to a greater extent compared with mature ewes. Increasing the level of post-mating nutrition had no significant effects on ewe productivity, litter size, lamb birth weight, skeletal development or post-natal lamb performance. However all aspects of lamb output were significantly (P<0.001) greater for mature versus adolescent ewes.

Table 1. Effect of early pregnancy nutrition and ewe maturity on foetal development and lamb performance

	Early Pregnancy Nutrition					Ewe Parity			
	H	M	L	s.e.d	Sig	Mature	Adolescent	s.e.d	Sig
Liveweight change (g/d)									
†Early Pregnancy	126^{c}	-26^{b}	-127^{a}	8.9	***	7^{B}	-25^{A}	7.2	***
‡Mid Pregnancy	102^{a}	112^{ab}	122^{b}	7.1	*	113	111	5.8	NS
Condition score change									
†Early Pregnancy	0.35^{c}	0.01^{b}	-0.22^{a}	0.03	***	0.00^{A}	0.09^{B}	0.03	***
‡Mid Pregnancy	-0.11^{a}	0.11^{b}	0.29^{c}	0.04	***	-0.02^{A}	0.22^{B}	0.04	***
Lambs born/ewe mated	1.47	1.37	1.45	0.16	NS	1.91^{B}	0.94^{A}	0.16	***
Lambs born/ewe lambed	1.91	1.74	1.84	0.13	NS	2.28^{B}	1.38^{A}	0.11	***
Lamb birth weight (kg)	4.50	4.46	4.47	0.13	NS	5.25^{B}	3.70^{A}	0.13	***
Crown-rump length (cm)	44.0	43.3	43.2	0.64	NS	46.4^{B}	40.6^{A}	0.94	***
Lamb growth rate birth to weaning (g/d)	233	233	236	8.7	NS	251^{B}	217^{A}	8.6	***

† Days 1-31 of pregnancy; ‡ Days 32-108 of pregnancy; Means within rows sharing the same superscript are not significantly different (P>0.05)

Conclusion The productivity of both adolescent and mature ewes, and the post-natal performance of their lambs, were unaffected by the level of feeding in the first month after mating. However lamb output at birth from adolescent ewes was lower than that of mature ewes due to a combination of smaller litter sizes and lower lamb birth weights.

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The effects of mineral block supplementation to ewes in late pregnancy on feed intake, IgG absorption and the level of faecal adhesion in the newborn lamb

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Introduction In recent years there has been increasing use of mineral blocks in the diets of sheep both at mating time and in pregnancy. However, recent work carried out at this institute (Joyce, 2000) found that lambs whose dams had access to mineral blocks had significantly lower IgG serum values at 24 hours than lambs whose dams had no access to mineral blocks. This experiment investigated further the effects of supplementing the pregnant ewe diet with mineral blocks on IgG absorption efficiency and on the level of faecal adhesion to the tail-end of the lambs in early life.

Materials and Methods On day 98 of pregnancy, sixty-six ewes scanned as twin bearing were selected and housed in individual pens. The ewes were offered a diet of grass silage *ad libitum* supplemented with 400g/ewe/day of a 19% CP concentrate. The level of concentrate supplementation was increased to 500g/ewe/day from day 120 of pregnancy until 24 hours post partum. The ewes were allocated to two treatments and the treatments balanced for ewe age and weight: T1, ewes only were given access to mineral blocks containing Ca 7%, Mg 6%, P 5%, Na 4% with the following trace elements (mg/kg) Cu 250, Co 200, I 400, Se 35, Zn 8000 & Mn 2000). Fresh water was available at all times and water intake was measured in the last week of pregnancy. Ewes that lambed between days 143-152 of pregnancy were hand milked following administration of 10 i.u. of oxytocin (Oxytocin S, Intervet Ltd) at 1, 10, and 18 hours post partum. Two 5ml colostrum samples were taken to determine IgG yield and concentration. Lambs were blood sampled using jugular venipuncture at 24 hours post partum. Single radial immunodiffusion (RID) kits (Bethyl Laboratories, Montgomery, Texas) were used to measure the IgG concentration of colostrum using the method of Fahey and McKelvey (1965). The zinc turbidity test (McEwan et al., 1970) was used to assay the lamb serum for immunoglobulin level. The level of faecal adhesion to the tail end region of the lambs was carried out at 48 hours post lambing using a score scale of 1-4 (1= no soiling, 4= very heavy soiling). Statistical analysis was carried out using the General Linear Model procedure (PROC GLM) of the Statistical Analysis System (SAS, version 6.12)

Results The ewe and lamb performance data are presented in Table 1. Ewes with access to mineral blocks (T1) had lower ($P<0.05$) intakes of silage DM (1.32 vs 1.39, SEM 0.023 kg) and ME (13.89 vs 14.52, SEM 0.021 MJ). Treatment had a highly significant effect ($P<0.001$) on water intake, with ewes having access to mineral blocks consuming more water and this was reflected in a higher unit total water:unit DM intake ($P<0.001$). Treatment had no effect on colostrum yield to 18 hours or total IgG yield to 18 hours. The lambs whose dams had access to mineral blocks (T1) had lower ($P<0.05$) serum IgG values and this was reflected in a lower colostral IgG absorption efficiency. When ewes had access to mineral blocks, their progeny had a higher level of tail-end faecal adhesion, the consistency and appearance of which gave the clear impression of incomplete digestion of the colostrum. Treatment had no significant effect on lamb growth rate to weaning ($P>0.05$).

Table 1.The effect of mineral block supplementation on ewe and lamb performance (L.S.M. $\pm$ S.E.M.)

Parameter	T1	T2	SEM	P
Voluntary water intake (l)	1.16	0.44	0.100	***
Unit Total Water Intake:Unit Total DMI	4.97	4.50	0.090	***
Colostrum yield to 18 hrs (ml)	1673	1924	114.5	ns
Total IgG yield to 18 hrs (g)	80.2	88.3	5.05	ns
Total IgG fed to 18 hrs (g)	31.6	32.7	3.33	ns
Lamb serum IgG at 24 hrs (g/l)	4.7	18.9	2.20	*
% Colostral IgG absorbed	5.4	22.0	1.88	*
Lamb faecal adhesion score	1.8	1.0	0.13	*
Lamb growth rate to weaning (g/d)	297	320	11.1	ns

* $P<0.05$ ** $P<0.01$ *** $P<0.001$ ns = $P>0.05$

Conclusions The availability of mineral blocks to pregnant ewes resulted in higher water intakes. Lambs born to ewes who had access to mineral blocks in late pregnancy had lower serum IgG levels and lower efficiency of colostral IgG absorption than lambs born to non-mineral block ewes. Lambs born to ewes given access to mineral blocks had a higher level of rear-end faecal adhesion at 48h post partum, indicative of a higher passage rate of colostrum through the intestine and/or less complete digestion/absorption of the colostrum. Further investigation is necessary to determine which component(s) of the mineral block is responsible for these undesirable observations.

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The effects of a mineral supplementation when offered to pregnant ewes for the final 6, 4 or 2 weeks pre-partum on Immunoglobulin (IgG) absorption in their offspring

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Introduction The placenta prevents the transfer of maternal immunity to the foetus and consequently lambs are born hypoimmunocompetent. The IgG content in colostrum and its absorption into the blood stream has important consequences for lamb liveability in early life. Recent experiments carried out at this institute found that when ewes had access to a mineral block or the mineral component of this block in the form of powdered minerals in late pregnancy, the absorption of IgG by their offspring was reduced (Boland et al., 2003). Keane (2001) stated that it would appear that the lamb was pre-programmed in-utero for lowered IgG efficiency and that the problem lay with the lamb rather than to any altered characteristics of the colostrum. The aim of this experiment was to investigate the period of time necessary for high levels of mineral supplementation to the ewe to affect a reduction in IgG values in the progeny.

Materials and Methods Sixty single bearing ewes were selected at day 104 of pregnancy and randomly allocated to one of four dietary treatments. The basal diet was grass silage offered ad libitum which had 50kg of molassed sugar beet pulp added per tonne of fresh grass at the time of ensiling, supplemented with a commercially available concentrate (barley, beet pulp, citrus pulp, soya bean based) at a rate of 400 g per day from days 104 to 125 of gestation and 600 g/d from day 126 of gestation until lambing. The roughage/concentrate diets were supplemented with 48g of a specially formulated mineral/vitamin mixture containing Ca 6.5g, Mg 5.9g, P 4.9g, Na 4.0g, Zn 790 mg, Mn 200 mg, I 40 mg, Co 20 mg, Se 3.5 mg & Vit E 40 mg for 6 weeks (T1), 4 weeks (T2), 2 weeks (T3). Ewes in T4 (control) did not have access to supplemental minerals. The minerals were mixed with the concentrates each morning and offered to the ewes in individual pens. Ewes lambing between days 143-153 of gestation were hand milked at 1, 10 and 18 hours post partum following administration of 10 i.u. of Oxytocin (Oxytocin S; Intervet Ltd). Colostrum samples were taken at each milking and the lambs were blood sampled by jugular veinepuncture using a 5 ml vacutainer 24 hours post partum. The IgG content in the colostrum was determined by the method outlined by Fahey and McKelvey (1965) using single radial immunodiffusion kits (Bethyl Laboratories, Montgomery, Texas). The zinc sulphate turbidity test (McEwan et al., 1970) was used to analyse lamb serum for total immunoglobulin level. The data were analysed using the General Linear Model procedure (PROC GLM) of SAS v. 6.12.

Results Treatment had no effect on total colostrum yield to 18 hours or total IgG yield to 18 hours ($P>0.05$). In the treatments where ewes were offered supplemental minerals for either 6, 4 or 2 weeks, their progeny had significantly ($P<0.001$) lower serum IgG values and the efficiency of colostral IgG absorption was also lowered. Lamb weaning weight and daily growth rate from birth to weaning did not vary ($P>0.05$) between treatments. Progeny of ewes receiving no minerals tended to have a lower incidence of lameness, symptomatic of joint ill, in early life although the difference did not reach significance ($P>0.05$).

Table 1 The effect of mineral supplementation on ewe and lamb performance (LSM ± SEM)

Treatment	Minerals 6 wks	Minerals 4 wks	Minerals 2 wks	Control	SEM
Colostrum yield (ml)	1437	1661	1694	1553	125.8
Total IgG yield (g/l)	66.4	86.6	85.5	74.0	7.34
Total IgG fed (g)	44.2	46.5	42.8	41.2	2.79
Lamb serum IgG (g/l)	4.85[a]	8.51[a]	5.54[a]	22.21[b]	1.951
Colostral IgG absorbed (%)	6.90[a]	7.79[a]	7.22[a]	26.11[b]	2.436
Lamb weaning weight (kg)	34.0	35.7	36.6	34.1	1.55
Daily GR to weaning (g/hd/day)	254	278	272	253	13.4
Lamb lameness in early life %	66	45	57	35	14.2

[a,b] Means within rows with different superscripts are significantly different ($P<0.05$)

Conclusions Quite an unexpected finding from this experiment was that even a short supplementation period of just two weeks at the end of gestation had a significant negative impact on the ability of the lamb to absorb antibodies in early life, with no significant difference when the period of supplementation was longer. The high incidence of lamb lameness recorded, which broadly speaking was negatively related to the serum IgG values, in the current study is a major cause for concern. Further studies are required to determine the exact duration, the timing and level of the mineral supplementation which will seriously compromise the acquired immunity by the lamb.

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The effects of mineral supplementation to ewes in late pregnancy on Immunoglobulin G absorption by their lambs

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Introduction High levels of mineral supplementation to ewes in late gestation results in reduced blood serum immunoglobulin G (IgG) concentration and a lowered efficiency of colostral IgG absorption at 24h post partum (Boland et al., 2003). Given that lambs are born hypogammaglobulinemic and are dependent on the absorption of immunoglobulins from colostrum for immunity in early life, this decrease in serum IgG concentration is likely to present a significant challenge to the neonatal lamb in relation to disease susceptibility. The aim of this experiment was to determine which element(s) in the mineral supplement are having the greatest effect in reducing colostral IgG absorption and if the removal of this element(s) from the formulation would result in a return to what might be considered as normal immunoglobulin absorption values.

Materials and methods Following pregnancy scanning, 108 twin-bearing ewes were allocated to one of nine treatments. From day 98 of gestation the ewes were offered a diet based on grass silage ad libitum which was supplemented daily with 500g of a 19% crude protein concentrate. In addition, the ewes in each treatment received either a mineral/vitamin supplement or the same mineral supplement with one element not included, as follows:- T1, (control) no supplement; T2, (all) a supplement containing calcium (Ca), phosphorous (P), magnesium (Mg), sodium (Na), zinc (Zn), selenium (Se), iodine (I), manganese (Mn), cobalt (Co) and vitamin E (Vit E); T3, (-Zn) minus zinc; T4, (-P) minus phosphorous; T5, (-Se) minus selenium; T6 (-I) minus iodine; T7, (-Mg) minus magnesium, T8, (-Mn) minus manganese: T9, (-Co) minus cobalt. The mineral/vitamin supplement was offered at a rate and composition similar to that already reported when similar animals had access to mineral blocks (Boland et al., 2003). The mineral/vitamin supplement was mixed with the concentrate daily and offered to the ewes in individual pens. All ewes were hand milked at 1h, 10h and 18h post partum following the administration of 10 i.u. of Oxytocin (Oxytocin S, Intervet Ltd) and samples taken for IgG determination. Lambs were blood sampled at 24h to determine serum IgG values. The IgG content of colostrum was measured by the method of Fahey and McKelvey (1965) using single radial immunodiffusion (RID) kits (Bethyl Laboratories, Montgomery, Texas). Lamb serum was assayed for total immunoglobulin level using the zinc sulphate turbidity test (McEwan et al., 1970). Given the range of elements included in the supplement fed there was potential for interactions between different elements to disrupt the IgG absorptive process. The data were analysed using the General Linear Model procedure (PROC GLM) of SAS v. 6.12. The experiment was analysed as a randomised block design and the data subjected to analysis of variance providing treatment means with standard errors of the mean (S.E.M.).

Results Ewe and lamb performance data are given in Table 1. Ewes not receiving supplementary zinc (-Zn) or phosphorous (-P) yielded less colostrum to 18h than the ewes in the treatments where iodine and cobalt were omitted ($P<0.05$). There was no effect of treatment on total IgG yield to 18h or on lamb birth weight ($P>0.05$). The exclusion of iodine from the mineral/vitamin supplement resulted in lambs having acceptable serum IgG concentrations (19.9 g/l) and IgG absorption efficiencies (22.7%) at 24h that did not differ from the control ($P>0.05$) but were significantly higher than all of the other mineral/vitamin supplementation treatments ($P<0.001$).

Table 1 The effects of mineral supplementation on ewe and lamb performance (L.S.M. ± S.E.M.)

Treatment	Control	All	-Zn	-P	-Se	-I	-Mg	-Mn	-Co	S.E.M
Colostrum yield (ml)	1825^{bc}	1639^{abc}	1415^{ab}	1328^{a}	1622^{abc}	1901^{c}	1674^{abc}	1727^{abc}	1900^{c}	168.0
IgG yield (g)	91	78	84	80	86	93	88	94	84	8.1
Lamb birth weight (kg)	4.91	4.96	4.94	5.18	4.68	4.87	4.49	4.59	4.74	0.193
Serum IgG (g/l)	20.9^{c}	5.4^{ab}	8.4^{ab}	4.2^{a}	6.0^{ab}	19.9^{c}	5.7^{ab}	4.8^{a}	9.7^{b}	1.68
IgG absorption %	22.0^{d}	8.6^{ac}	9.6^{bc}	5.2^{a}	5.9^{ab}	22.7^{d}	6.9^{ac}	4.4^{a}	11.9^{c}	1.77

^{a,b,c,d} Means within rows with different superscripts are significantly different ($P<0.05$)

Conclusions Feeding supplementary iodine at the level used in the current experiment to ewes in late gestation resulted in a reduction in the ability of their offspring to absorb colostral IgG and hence a reduced serum IgG concentration in these lambs. Furthermore, when iodine was excluded from the supplement, lamb serum IgG values returned to normal. Further studies are required to determine the level, timing and mode of action of iodine supplementation that will reflect negatively on IgG absorption efficiency. It is not clear if iodine altered IgG absorption through it's own action or via interactions with other elements. This aspect also merits further study.

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Determination of the *in situ* degradation characteristics of whole-crop pea (*Pisum sativum* L.) silages differing in condensed tannin content

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Introduction Since the ban of meat and bone meal and fishmeal the UK farming industry has turned to soyabean meal as the major source of protein for inclusion into ruminant diets. Public concerns over GM foods and traceability of foodstuffs have turned attention to home-grown protein sources such as legumes. Peas have historically been fed as meal, however, the use of whole-crop peas as silage is a relatively new idea. The presence of condensed tannin (CT) has the potential to ruminally protect protein from degradation (Min *et al.*, 2003). However the degradation characteristics of different pea silages varying in CT have not been determined. This experiment tested the hypothesis that pea silage with a higher CT level would have a reduced effective degradability.

Materials and methods Two varieties of, spring-sown, semi-leafless, combinable peas that differed in CT content were grown during 2002. The pea variety Racer contained CT and Croma contained no CT. Peas were cut at growth stage 206 (Knott, 1987), wilted for 36hrs, chopped using a self propelled forage harvester, which applied a bacterial inoculant (Wholecrop Legume, Biotal, UK) at a rate of 4l/T fresh weight, and were ensiled in separate concrete walled bunker silos. Core samples from each clamp were obtained for the *in sacco* study. Four mature ruminally cannulated wethers were fed a standard diet of hay and concentrate (70:30 DM basis) in two equal meals per day at 08:00 and 20:00 at 1.05 times maintenance. Approximately 8g of fresh silage was weighed into polyester bags which were sealed by passing the neck of the bag through a brass curtain ring (18mm diameter) and secured using an elastic band. Bags were incubated *in situ* for either 2, 4, 8, 16, 24, 36, 48 or 72hrs in a continuous changeover incubation series. Upon withdrawal bags were washed and then dried at 60°C. Bag residues were analysed for ash and nitrogen (Kjeldahl) and fitted to the model of Ørskov and McDonald (1979; $P=a+b(1-e^{-ct})$), effective degradability (ED) was calculated at a outflow rate (k) of 0.08/hr using $P=a+[bc/(c+k)](1-e^{-(c+k)t})$. Water-soluble loss (WSL) was determined by the method of Weisbjerg *et al.* (1990) and corrected effective degradability (C ED) calculated (C ED=WSL+[(100-WSL)/(100-a)*(ED-a)]). Curves were fitted using SigmaPlot (version 4.0), curve parameters were analysed using ANOVA by Genstat (version 6.1).

Results and discussion The degradation characteristics of the pea silages, shown in Table 1, differed statistically ($P<0.05$) for all fitted values, with the pea containing no CT having larger a, b and c values. The goodness of fit (r^2) for all the curves is above 0.9 except for the CT absent nitrogen curve, this was due to there being more variation between replicates at the earlier time points. The rate of nitrogen degradation in the CT absent variety is over twice that of the CT containing variety. ED values calculated at a rate of 0.08/h and **t=**∞ indicate that both pea silages are highly rumen degradable. However half of the 'a' term measured for DM and N is water-soluble whereas the rest is small particle losses. The C ED values are similar to the ED for DM but are 8.7% and 8.3% lower for the nitrogen fraction in the CT absent and CT containing peas respectively.

Table 1. The DM, OM and nitrogen degradation characteristics of whole-cop pea silages differing in condensed tannin (CT) content as determined *in situ*

	Dry matter			Organic matter			Nitrogen		
	CT -	CT +	s.e.d.	CT -	CT +	s.e.d.	CT -	CT +	s.e.d.
a	0.44	0.42	0.009	0.41	0.40	0.011	0.78	0.74	0.011
b	0.41	0.40	0.008	0.43	0.41	0.014	0.17	0.19	0.008
c	0.09	0.08	0.006	0.09	0.09	0.006	0.26	0.11	0.080
ED†	0.657	0.620		0.638	0.617		0.910	0.850	
WSL (proportion of a)	0.472	0.484		n.d.	n.d.		0.586	0.482	
C ED†	0.666	0.656		n.d.	n.d.		0.831	0.701	
r^2	0.93	0.92		0.98	0.98		0.85	0.96	

(C)ED = (corrected) effective degradability, † calculated at outflow rate of 0.08/h & t=∞, n.d. = not determined, WSL = water soluble loss

Conclusions Both peas varieties are highly rumen degradable with the presence of CT having a protective effect on DM and N degradability. The use of ED for whole-crop pea silages gives an overestimate of potential rumen degradability, due to the high water-soluble proportion of the 'a' term, therefore use of C ED would be recommended. With pea silage having a high level of readily degradable rumen N it would be beneficial to feed it in conjunction with a readily available energy source such as maize silage.

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The influence of CLA supplementation and heavy weights on the histochemical profile of *m. longissimus dorsi* from fatteners.

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Introduction The combination of genotypes (100% stress negative) and other treatments, especially nutritional, can give good results in achieving fast lean growth with good meat quality (Cameron et al., 1998). The reasons of negative relationships among growth performance and meat and eating quality traits are not completely clear. Increased rate of muscle growth can lead to changes in histochemical muscle properties such as an increase in the proportion of type IIB fibres which can result in less tender and less red meat (Warriss, 2000). In terms of a nutritional treatment, which can be beneficial to improving meat and eating quality, special attention in recent years has been paid to (CLA). Therefore, the aim of this study was to determine the influence of dietary CLA supplementation on histochemical profile of *m. longissimus dorsi* from pigs slaughter at heavier weights (129.9 kg).

Materials and methods The research was carried out on forty cross-bred fatteners (castrates and gilts) coming from a very popular cross in Poland (Large White × Landrace sows and Pietrain boars as terminal sires) weighing on average 70 kg, divided into two groups, twenty animals in each. 2% of CLA (Endor Ukd, Henkel, Germany) for experimental group was administered via the feed during the morning feeding. 2% of sunflower oil was used to make up for the CLA in feed for the control group. Muscle samples for histochemical analysis were taken from the *m. longissimus* on the right side of the carcass immediately after slaughter between the 13th and 14th ribs and deep within the muscle. Two different staining methods were used to determine muscle fibre types: The activity of diaphorase was detected using specific histochemical tests (Dubovitz et al., 1973). The incubation medium contained nicotinamide adenine dinucleotide ($NADH_2$) and nitro blue tetrazolium (NBT) and myofibrillar ATPase activity. Stained sections including 150 to 200 fibres were examined by a computerized image analysis system (Multi Scan Base98) and the percentage distribution of fibre types and the fibre diameters calculated according to Brook and Kaiser (1970). The data were analysed by analysis of variance. Data are presented as means ± SD.

Results There were significant differences in both the percentage of fibre types, and their diameter, between the control and CLA-treated groups tested by both histochemical methods. Muscles from CLA treated pigs had a higher percentage of white fibres, and a lower percentage of red fibres ($P \leq 0.05$), than muscles from control animals. White fibres had a greater diameter and red fibres a smaller diameter, in the CLA-treated pigs ($P \leq 0.05$) than in the control pigs. So, CLA increased both the number and diameter of white fibres, and correspondingly reduced the number and diameter of red fibres. The distribution and size of intermediate fibres was unaffected by CLA.

Table 1.The effect of dietary CLA supplementation on percentage and diameter of muscle fibres in *m. longissimus dorsi* according to ATPaze and diaphorase activity ($\bar{x}$ ± SD).

	Percentage content					
	ATPase			Diaphorase		
	Control	CLA	Sign.	Control	CLA	Sign.
White fibres	60.8 ± 3.9	72.9 ± 1.9	*	61.0 ± 5.2	73.2 ± 1.8	*
Intermediate fibres	17.1 ± 2.1	15.8 ± 2.2	NS	15.5 ± 2.2	14.4 ± 1.3	NS
Red fibres	22.1 ± 2.3	11.3 ± 2.4	*	24.7 ±2.9	11.9 ± 1.5	*
	Fibre diameter [μm]					
White fibres	85.1 ± 1.5	92.4 ± 2.9	*	85.4 ± 1.7	93.0 ± 2.6	*
Intermediate fibres	80.9 ± 2.4	75.6 ± 3.1	NS	80.3 ± 3.2	74.9 ± 2.8	NS
Red fibres	91.2 ± 3.3	83.1 ± 3.6	*	90.8 ± 3.9	83.3 ± 3.2	*

Means in rows marked with * are significantly different at $P \leq 0.05$

Conclusions The histochemical results from this experiment have shown that dietary CLA supplementation affected the percentage and diameters of the muscle fibres. The significantly higher diameter of white fibres and the lower diameter of red fibres in the muscle of the experimental group suggest an negative effect of CLA in feed on muscle physiology because of the increase in fibre hypertrophy in the muscle of pigs slaughtered at heavier weights with the stress susceptible Pietrain breed

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Growth promoter action and calpastatin mRNA expression in porcine skeletal muscle

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Introduction Studies on growth promoter action can give an insight into the mechanisms of growth control. Calpain genes encode a family of proteins responsible for calcium-dependent proteolytic activity in mammalian cells. The ubiquitous enzymes μ- and m-calpain are activated *in vitro* by μM and mM calcium ion concentration, respectively. Both these calpain isoforms have been implicated in myofibrillar protein turnover and are regulated by calpastatin, a highly specific inhibitor protein. Overexpression of calpastatin has been strongly associated with skeletal muscle hypertrophy and meat toughness in livestock; a plausible mechanism has been that inhibition of calpain reduces myofibrillar protein degradation while protein synthesis continues unchanged *in vivo*, whilst inhibition of calpain *post mortem* prevents proteolytic cleavage of myofibrillar proteins. In pigs there are at least three calpastatin promoters (1xa, 1xb, 1u) with transcription factor binding motifs potentially responsive to β-agonist and IGF-1/calcineurin–mediated signalling pathways (Parr *et al.*, 2001). The objective of the current study is to compare the expression patterns of different calpastatin mRNA transcripts in pigs treated with two different classes of growth promoters: clenbuterol treatment for 24 h and porcine somatotropin (pST) for 7 d.

Materials and methods Two trials were carried out. Individually penned Large White type pigs were used in both trials. In Trial 1, 23 pigs were fed a standard finisher diet for 5 weeks. On the day before slaughter, 12 pigs received diet supplemented with 5 ppm of the β-agonist clenbuterol. In Trial 2, 21 pigs were fed a high protein diet, *ad libitum*, with a specific amino-acid composition, formulated to meet the essential requirements for pigs treated with pST. Seven days prior to slaughter, 10 animals were injected with 1 ml sterile water (control) and the remaining pigs received a daily dose of 5 mg/ml pST (Reporcin™, Alpharma, Australia) dissolved in 1 ml sterile water. For both trials, samples of *longissimus dorsi* were taken within 5 min of slaughter and frozen immediately in liquid nitrogen at -70°C prior to mRNA extraction (Parr *et al.*, 2001). Effectiveness of treatment was assessed by assay of muscle glycogen and plasma IGF-1 for Trials 1 and 2, respectively. The expression pattern of different calpastatin mRNA transcripts was quantified by reverse transcriptase PCR using the Real Time Taqman® (ABI Biosystems) procedure. Three Real Time PCR reactions targeting the XL and L regions of porcine calpastatin were designed to quantify the abundance of mRNA for 1xa, 1xb and 1u transcripts. A generic reaction to measure total calpastatin mRNA was also designed. Ct values were converted to ng of total RNA using a calibration curve and mRNA abundance was corrected with reference to actin mRNA. Data are expressed as mean ± SED. The effect of treatment on mRNA abundance of each transcript was analysed using Student's t-test for unpaired data.

Results Clenbuterol treated animals had significantly less muscle glycogen (23.6 ± 3.6 μmoles/mg) than control animals (52.7 ± 3.6 μmoles/mg, $p < 0.001$). Plasma IGF-1 concentration was significantly increased in pST treated pigs (625 ± 48 ng/ml) compared to control animals (423 ± 48 ng/ml, $p < 0.001$). Administration of clenbuterol caused a 51% increase ($p < 0.05$) in abundance of the total calpastatin mRNA (Figure 1). Although not significant, increases were seen in 1xa, 1xb and 1u transcripts that could account for the overall increase. In the pST trial, total calpastatin mRNA decreased by 43% after 7d treatment ($p < 0.01$), which could be explained by significant decreases in 1xa ($p < 0.01$), 1xb ($p < 0.05$) and 1u ($p < 0.05$) transcripts (Figure 2).

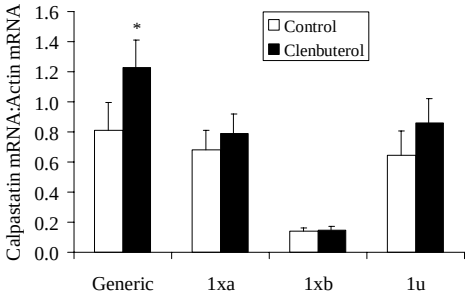

Figure 1 Effect of clenbuterol on the abundance of different calpastatin transcripts (* $p < 0.05$)

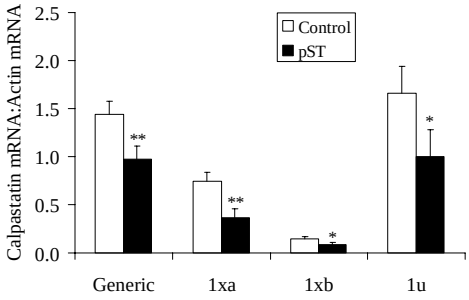

Figure 2 Effect of pST on the abundance of different calpastatin transcripts (* $p < 0.05$; ** $p < 0.01$)

Conclusions Both β-agonist and pST treatment are known to causes muscle hypertrophy in *longissimus* muscle in pigs. A plausible mechanism for β-agonist treatment is that overexpression of calpastatin leads to a reduction in myofibrillar breakdown by the calpain proteolytic system. However, the present data indicate that although pST treatment had a marked effect on calpastatin expression, the response was a decrease in mRNA abundance. Therefore, whilst calpastatin expression is responsive to both growth promoters, the mechanism by which they induce hypertrophic growth is likely to be different for each of them.

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Variability in pigmeat quality: a multifactorial investigation

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Introduction Although feeding pigs *ad libitum* is known to result in increased tenderness (e.g. MLC, 1989), there would be benefits in reduced cost of production if this could be obtained without the concomitant reduction in feed efficiency and carcass leanness. The *ad libitum* effect on tenderness could be due to higher lean tissue growth rate (LTGR) and associated increased protein turnover and muscle enzyme activity, but other factors may also contribute, such as reduced feeding stress compared to restricted feeding. The aim of this trial was to assess the eating quality of pork from pigs reared in a range of housing and nutritional treatments, designed to give a wide variation in LTGR.

Materials and methods The experiment was designed as a 2 x 2 x 2 x 2 factorial (total of 16 treatments), with 2 feeding regimens (*ad libitum* or restricted), 2 nutrient intakes (100 or 85% of *ad libitum* intake; achieved by dietary dilution to lower DE from 13.8 to 9.4 MJ/kg, and for restricted regimen pigs, an increase in nutrient density from 13.8 to 16.2 MJ/kg), 2 group sizes (small = 3, part-slatted building, 1.6 m^2/pig; or large = 18, fully-slatted building, 0.64 m^2/pig) and two slaughter points (by age = 160 days or weight = 95kg). A total of 864 pigs were used, initial weight ~ 30kg, progeny from white hybrid sows (predominantly Large White x Landrace) and Large White boars. Pigs on restricted feeding were fed twice daily, according to the average pen weight of the preceeding week. Feed intake was recorded on a pen basis. Pigs were individually slap marked and weighed prior to slaughter, when data were collected on hot carcass weight, backfat depth, pH_{45} and temperature of *longissimus dorsi*. The next day, the primal loin from one side of each pig was cut and backfat and muscle depth (P_2 mm), ultimate pH and temperature of *longissimus dorsi*, Minolta colour readings and drip loss (1 chop) recorded. The rest of the hind loin was stored at 1°C until day 10, when a series of chops were taken for shear force measurement and sensory analysis. A trained taste panel was used to assess juiciness, tenderness, pork, boar and abnormal flavour and overall acceptability using a 24 category scale (1 = extremely weak/low to 24 = extremely strong/high). Data were analysed by analysis of variance, using pen data for feed parameters, and individual pig data for growth, carcass and eating quality assessment.

Results Pigs fed *ad libitum* consumed more feed and energy than those restrictively-fed. Pigs fed at 100% intake ate less feed per day, but had a higher energy intake compared to 85% groups. A feeding regimen by nutrient intake interaction occurred in daily DE intake, where dietary dilution under *ad libitum* feeding did not reduce intake at a level comparable with 85% restricted feeding. Average daily gain varied considerably across treatments, and was significantly higher for *ad libitum* compared to restricted-fed, and 100 versus 85% intake pigs. There was a significant effect of feeding regimen on tenderness, which was reduced but not abolished by including daily gain as a covariate. Stepwise regression analysis explained 16.1% of the variation in tenderness and found taste panel session to be the best predictor (10.8 %, P<0.001), followed by feeding regimen (4.3 %, P<0.001) then daily gain (0.7 %, P<0.01).

Table 1 Means of pen feed intake and individual growth performance and eating quality for 4 of the 16 treatments

Feed regimen (F)	Ad libitum		Restricted		s.e.d.	Sig.	Sig.	Sig.
Nutrient intake (N)	100	85	100	85		F	N	F x N
Number of pens (pigs)	42 (207)	42 (205)	42 (204)	42 (196)				
Daily feed per pig (kg)	2.15^{i}	3.13^{j}	1.47^{k}	1.46^{k}	0.063	***	***	***
Daily DE per pig (MJ)	30.0^{a}	27.9^{b}	24.5^{c}	20.5^{d}	0.629	*	*	*
Final weight (kg)	96.6	93.2	84.6	79.7	1.66	***	***	ns
FCR	2.61^{a}	4.04^{b}	2.40^{c}	2.81^{d}	0.075	***	***	***
Average daily gain (kg)	0.845	0.763	0.649	0.565	0.0105	***	***	ns
Fat depth (P_1+P_3, mm)	24.1^{a}	19.0^{b}	17.7^{c}	15.7^{d}	0.42	***	***	***
Juiciness	12.6	12.7	13.1	12.9	0.23	*	ns	ns
Tenderness	14.5	14.1	13.4	13.0	0.29	***	*	ns
Pork flavour	13.6	13.7	13.7	13.7	0.17	ns	ns	ns
Abnormal flavour	2.4	2.3	2.6	2.5	0.12	*	ns	ns
Boar flavour	1.7	1.6	1.6	1.7	0.10	ns	ns	ns
Overall acceptability	12.9	13.0	12.5	12.3	0.24	**	ns	ns
Shear force (N)	52.5	52.6	58.3	56.9	0.84	***	ns	ns

abc/efgh/ijk Means followed by different superscripts are significantly different at P<0.05/P<0.01/P<0.001 respectively

Conclusions These results show that although a large part of the variation in eating quality of pork, particularly tenderness, can be explained by variation in growth rate, other factors are implicated. Feeding regimen was the primary experimental variable affecting tenderness, which was significant even when the data were corrected for growth rate.

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The effect of highly fermentable non-starch polysaccharides and energy intakes on pig performance and pork quality

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Introduction In recent pig nutrition the use of fibre-rich feed ingredients is increasing. In general, utilisation of energy from fermentable non-starch polysaccharides (NSP) are considered to be approximately 70 % of the energetic efficiency of digestible starch. According to Schrama *et al*. (1998) growing pigs are able to use energy from highly fermentable NSP (sugar beet pulp silage) as efficient as energy from digestible starch from tapioca. However, an issue is risen whether the source of energy affects the pig performance and slaughter quality, and if the effect of energy sources are modified at different feeding levels. The aim of the present study is to compare the effect of highly fermentable NSP with starch and oil at two energy intakes on finishing and slaughter performance of pigs and pork quality.

Materials and methods A total of forty-two hybrid individually housed pigs were used in the trial with an initial body weight of 48±4 (sd) kg. The experimental treatments were arranged in a 3x2 factorial design, with three energy sources (maize starch, soya oil and sugar beet pulp, all added to basal diet) at each of two energy levels. Within each energy level the daily nutrient intake were the same regarding to digestible protein, ileal digestible lysine and other amino acids, vitamins and minerals. The treatments were realised as an isocaloric proportion of daily nutrient intake derived from each energy source (0.2 MJ DE/kg$^{0.75}$) above the nutrients from basal diet. It was equal with daily 9 g/kg$^{0.75}$ highly fermentable carbohydrate (NSP), 10 g/kg$^{0.75}$ starch (Starch) or 5 g/kg$^{0.75}$ digestible fat (Oil). The DE intakes were 2.4 and 3.4 times maintenance requirement at low and high energy levels, respectively. The pigs were slaughtered at 106±3 (sd) kg body weight. The chemical body composition was determined according to Kotarbinska (1971) and lean %, backfat thickness (P2), *m. longissimus dorsi* diameter, pH45 and pH24, drip loss and intramuscular fat content in *m.longissimus dorsi* and *m. quadriceps femoris* were measured. A general model was used for statistic analysis: $Y_{ijk} = \mu + EL_i + ES_j + EL_i x ES_j + e_{ijk}$ where μ -mean; EL_i–energy level i=low, high; ES_j–energy source j=NSP, starch, oil; e_{ijk}–error.

Results The results of the trial is seen in Table 1. Data show that finishing and slaughter performance and meat quality were not affected by energy source and there was no interaction between energy level and source. However, the energy level effected the average daily gain, feed conversion, protein and fat deposition. Lean % was lower at low energy intake due to thinner backfat ($P<0.05$). The diameters of *m.l. dorsi* were not statistically different at low and high energy levels. The pH values of *m.l. dorsi* both 45 minutes and 24 hours *post mortem* were influenced by the energy intake. The pigs received lower energy levels had lower pH values and the muscle were likely PSE. However, there was no difference between treatments in drip loss, and the average of 82.8 g/kg can be considered a normal value. The intramusclar fat content in *m.l. dorsi* and *m.q. femoris* was not affected by energy intake and energy source ($P>0.05$).

Table 1 Effect of energy source and level on finishing and slaughter performance of pigs and pork quality (a, b $P<0.05$)

	energy level		**energy source**			
	low	**high**	**NSP**	**Starch**	**Oil**	*s.e.m.*
Average daily gain (g/day)	453^a	785^b	642	617	599	29.6
Feed conversion ratio (kg/kg)	4.25^a	3.32^b	3.88	3.87	3.60	0.11
Protein deposition (g/day)	60^a	92^b	79	76	74	3.2
Fat deposition (g/day)	109^a	255^b	177	184	185	13.8
Lean %	55.3^a	53.6^b	54.2	54.9	54.3	0.29
Backfat thickness P2 (mm)	17.3^a	20.1^b	19.1	18.0	19.0	0.49
M. l. dorsi diameter (mm)	52.9	51.3	52.7	52.5	51.2	0.85
pH45	5.84^a	6.12^b	5.99	6.00	5.94	0.05
pH24	5.35^a	5.73^b	5.46	5.60	5.55	0.05
Drip loss (g/kg)	80.3	85.4	91.5	77.8	79.2	6.38

Conclusions Results of the present study demonstrate that the energy level influences the finishing performance and the slaughter quality. Feeding highly fermentable NSP causes no detrimental effect on finishing and slaughter performance of pigs and pork quality compared to starch and oil. Based on present data it can be suggested that highly fermentable NSP-rich ingredients like sugar beet pulp are suitable in pig feeding, that may have economical consequences.

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Effect of dietary oil type and protein level on carcass and fat qualities in pigs

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Introduction The use of dietary fats and oils to manipulate the fatty acid profile in meat animals to produce higher quality, healthier meat has been well documented, for example by Enser, *et al* (2000). In Ghana and other developing countries, agro-industrial by products containing oil have been examined because they reduce feed costs. These include palm products and inclusion levels have been recommended (Okai, 1998). However, there is no information on the effect of these palm products on the fatty acid profile and the quality of pork and pork fat. The objective of this study was to evaluate the effects of palm and palm kernel oils on the fatty acid composition of pork fat and fat firmness.

Materials and methods Sixty crossbred pigs, (0.5 Duroc, 0.25 Large White, 0.25 Landrace), equal numbers of males and females and initial mean live weight of 40kg were fed one of six diets in a 2x3 factorial design with 3 oil types (40 g/kg) and 2 lysine levels (HL-11 and LL –7 g/kg). The oils were: soya bean oil (SBO), palm oil (PO), and palm kernel oil (PKO). Pigs were housed in groups of 6 in straw-based pens and fed *ad lib*. Animals were slaughtered as they attained an average live weight of 100 ± 10 kg. Measurements taken after slaughter were cold carcass weight, pH45 min., pH24h. in *m longissimus*, P2 backfat thickness and backfat firmness at 2^{o}C with a digital penetrometer. Analysis of backfat fatty acid composition was by gas-liquid chromatography following extraction into chloroform. Data were analysed by general linear model (Minitab 13) with oil type and lysine level as main factors.

Results Means for carcass weight, P2, pH45 and pHu, drip loss and backfat firmness are given in Table 1. Table2 shows the means for fatty acid composition. Oil type did not have a significant effect (P> 0.05) on carcass quality **(**Okai, 1998**).** However**,** PKO increased the concentration of saturated fatty acid (SFA): lauric (12:0), myristic (14:0), palmitic (16:0) and stearic (18:0) acids and decreased linoleic acid (18: 2), consequently making the fat firmer (Wood *et al*, 2003). The LL diet increased SFA concentration and reduce 18:2, producing firmer fat.

Table 1 Effect of dietary oil types and protein levels on pork carcass quality and backfat firmness

	PKO	PO	SBO	Sed	Sig	HL	LL	Sed	Sig.
Cold carcass	74.5	73.3	73.0	2.43	ns	71.6	75.7	1.98	*
wt (kg)	12.7	13.2	13.6	0.98	ns	12.8	13.6	0.80	ns
P2 (mm)	6.3	6.3	6.4	0.06	ns	6.3	6.3	0.06	ns
pH45	5.4	5.4	5.5	0.03	ns	5.4	5.5	0.03	ns
pHu	4.3	4.3	4.9	0.63	ns	5.0	4.2	0.52	ns
Drip loss									
(g/100g)	952^{b}		810^{a}	28.20	***	814	877	23.00	**
Fat firmness	773^{a}			60.75	**	651	711	49.54	ns
Shoulder **(Pe)**	781^{b}		672^{ab}						
Loin **(Pe)**	588^{b}								

Pe-penetrometer units. NS not significant; *** P ≤ 0.05; ** P ≤ 0.005; *** P ≤ 0.001**

Table 2 Effect of dietary oil type on backfat fatty acid composition (g/100g tissue)

	PKO	PO	SBO	Sed	Sig	HL	LL	Sed	Sig.
12:0	1.14 ^{b}	0.06^{a}	0.06^{a}	0.06	***	0.40	0.44	0.04	ns
14:0	3.86^{b}	1.14^{a}	1.14^{a}	0.11	***	2.01	2.09	0.09	ns
16:0	24.30^{c}	22.84^{b}	21.4^{a}	0.39	***	22.45	23.20	0.32	*
18:0	13.01^{b}	11.68^{a}	11.60 ^{a}	0.40	**	11.67	12.53	0.32	*
18: 1n-9	33.95^{a}	39.11^{b}	33.04 ^{a}	0.68	***	34.81	35.92	0.55	ns
18: 2 n-6	12.6 ^{a}	14.92 ^{b}	21.86^{c}	0.66	***	17.59	15.36	0.05	***
18: 3 n-3	1.31 ^{a}	1.45^{ab}	1.53^{c}	0.09	***	1.91	1.53	0.06	***
18:0/18: 2	1.1^{c}	0.8^{b}	0.5^{a}	0.05	***	0.7	0.9	0.04	***
P: S	0.3^{a}	0.5^{b}	0.7^{c}	0.03	***	0.6	0.5	0.02	***
Total lipid	81.0	79.5	81.0	1.95	ns	78.8	82.2	1.59	*

Pe-penetrometer units. NS not significant**; * P ≤ 0.05; ** P ≤ 0.005; *** P ≤ 0.001**

Conclusion The results show varying effects of oil type on fatty acid composition and backfat firmness, with PKO producing the most saturated and firmest fat.

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Effect of stocking rate and split-marketing on performance of pigs and pigmeat output

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Introduction Intensive production systems require that inputs and facilities be used in the most efficient manner. Stocking strategy can have a significant effect on the output from pig units. Crowding can result in depressed pig performance while understocking can cause reduced pigmeat output. Alternatively, split-marketing pigs on a number of days (SM) can result in lower within pen variation in pig weight and improved growth rate of pigs remaining behind. Two experiments were conducted to determine if performance of pigs and pigmeat output per unit area could be improved either by varying the stocking density (by increasing group size) or by engaging in split-marketing.

Materials and methods In experiment 1 four hundred and three crossbred pigs (progeny of meatline sires out of F1 LW*LR sows) were allotted at random to single sex groups (n=30) of 11, 13 or 15 pigs per pen. All pens were of equal size (11.04 m^2), resulting in three treatments of increasing stocking density: 1.00 pig/m^2, 1.18 pigs/m^2 and 1.36 pigs/m^2. Initial weight of pigs was 36.7 ± 2.0 (mean ± s.d.) kg and all pigs had free access to a standard diet (barley, wheat, soyabean meal, synthetic amino acids, minerals and vitamins; CP 188g/kg, CF 33 g/kg, DE 13.6 MJ/kg, lysine: DE 0.81 g/MJ) until they reached slaughter weight. In experiment 2 twenty-six single sex groups of 13 or 14 pigs were assigned at random to one of three treatments: entire pen group sold on one day (1D), pen group sold on two days 14 days apart (2D: 40 % on day 1 and 60 % sold on day 2) and pen group sold on three days, each seven days apart (3D: 25 % on day 1, 25 % on day 2 and 50 % on day 3). Initial weight of pigs was 38.8 ± 2.1 (mean ± s.d.) kg. Pigs were fed the same diet as experiment 1, but in a wet mix (3:1 water: feed), three times daily (0.24 at 0800 h, 0.42 at 1400 h and 0.34 at 2000 h). Pigs were slaughtered at 99.4 ± 3.5 and at 90.0 ± 2.3 (mean ± s.d.) kg in experiments 1 and 2, respectively. Backfat and muscle depths were measured 6 cm from the midline of the split carcass midway between the 3rd and 4th last rib using the Hennessy Grading Probe approximately 45 minutes post mortem. Carcass lean meat (LM) was estimated according to the formula: LM (g/kg) = $534.1 - 7.86*X_1 + 2.66*X_2$ where X_1 and X_2 represent backfat and muscle depths in mm. Performance of pigs (average daily gain (ADG), average daily feed intake, feed conversion ratio (FCR), carcass ADG, carcass FCR, carcass lean, backfat and muscle depth and kill out proportion) and output per unit area (measured as carcass and lean gains per m^2 per year) were calculated for both experiments. Output per year was based on daily output*365*0.9 (for 90 % occupancy rate) in experiment 1 and on cycle length (days from start until the last pig left, plus three days for refilling), in experiment 2. Statistical analysis was by the GLM procedures of SAS Inc., Cary, N. Carolina for a randomised complete block design in both experiments. Single degree of freedom contrasts were used to compare the effects of 11v15 pigs and 13v15 pigs in experiment 1, and initial weight was used as a covariate in experiment 2.

Results Treatment had no effect on growth rate, feed intake, feed conversion ratio, carcass ADG, carcass FCR, carcass lean, backfat or muscle depths or kill out proportion in either experiment (P>0.05). Treatment did have an effect on pigmeat output for both strategies (Table 1). Increasing stocking density caused increases of 34 % (11 to 15 pigs per pen) and 12 % (13 to 15 pigs per pen) in carcass and lean gains per m^2 per year (P<0.001). Split-marketing pen groups on two or three days increased cycle length by 12 to 13 % compared to selling on one day (P<0.001). Although within pen variation in cold weight decreased with increase in number of sale days (P<0.001), both carcass and lean gains per m^2 per year decreased by 12 to 13 % when more than one sale day was involved (P<0.01 for carcass gains and P<0.001 for lean gains). There were no treatment by sex interactions detected in either experiment.

Table 1 Effect of stocking strategy on pigmeat output (ls means)

Stocking density					P-value[1]		
	11	13	15	sem	Overall	11v15	13v15
Carcass gain per pig per day, g/day	716	722	704	9.7	0.46	0.42	0.22
Carcass gain per m^2 per year, kg/m^2/yr	225	268	301	3.6	***	***	***
Lean gain per m^2 per year, kg/m^2/yr	128	153	172	2.0	***	***	***

Split-marketing					
	1D	2D	3D	sem	P-value[1]
Cycle length, days	67.7	75.9	76.7	0.39	***
Carcass gain per m^2 per year, kg/m^2/yr	367	328	327	7.0	**
Lean gain per m^2 per year, kg/m^2/yr	214	189	189	4.4	***
Variation in cold weight in pen	5.27	3.81	1.74	1.28	***

[1] ** P<0.01 *** P<0.001

Conclusions The manner in which a pen is stocked or in which pigs are marketed did not affect individual pig performance but did have a significant effect on the pigmeat output per unit area. Increasing the stocking density within the range examined here resulted in increased output per pen, but split-marketing had the converse effect of decreasing output. Facilities were used most efficiently at the highest stocking density and by marketing the pen group on a single day.

Factors that influence the dairy cow farmers in Cornwall (U.K) to select a marketing channel

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Introduction Marketing channels used by farmers are of great importance to the prosperity of farming due to the structure of farming, the fact that agricultural products tend to be "undifferentiated" and the remoteness of the agricultural producer from the final consumer (Ritson 1985). Generally, little is known about the strategic management process of farmers and particularly about the factors and the farmers' characteristics that influence them to choose a particular marketing strategic alternative. This paper aims to examine the factors affecting the choice of marketing channel by dairy cow farmers in the County of Cornwall in UK.

Materials and methods This study was conducted through a postal survey. A seven page questionnaire was used to identify the marketing channels that were used by farmers, the characteristics of their farms and the farmers themselves as well as the factors that influence them to adopt a particular marketing channel. The questionnaire was piloted in the spring of 2003 in 34 dairy cow farmers operated in Cornwall. The main survey conducted in the summer of 2003 in a sample of 306 dairy cow farmers in the County of Cornwall in U.K. The effective response rate was 17%. The sample for the pilot survey was derived randomly from membership lists of the NFU South West Office while the main survey was conducted on other NFU members. Those lists included 340 dairy cow farmers operating in the County of Cornwall. In this study a one way chi-square analysis was used in order to assess the association between farm's and farmer's characteristics and the selection of each identified marketing channel. This test was performed as the expected values were more than five in all categories of the examined variables for each marketing channel (Brymar and Cramer, 1997). The The Kruskal - Wallis non parametric one way ANOVA was used in order to identify the relationship between each of the factors affecting the choice of marketing channel and the selection of a particular marketing outlet.

Results The results of the survey identified five marketing channels. The marketing channels selection and utilisation for dairy cow farmers in the County of Cornwall in U.K. are illustrated in Figure 1 (below). The chi – square analysis indicated a significant association between sales to milk marketing cooperative group and holding responsible position in farming organisations (χ^2 =18.241, df=1, P<0.001), holding responsible position in a non-farm business that the farmer owns (χ^2 =25.138, df=1, P<0.001), farm income (χ^2 =15.310, df=4, P<0.01), financial performance (χ^2 =9.586, df=2, P<0.01), age (χ^2 =7.828, df=3, P=0.05), educational level (χ^2 =21.862, df=4, P<0.001), milk price (χ^2 =10.414, df=2, P<0.01), farm allocation (χ^2 =16.828, df=2, P<0.001), volume of milk production (χ^2 =7.517, df=2, P<0.05), area rent from other farmers (χ^2 =20.138, df=2, P<0.001), milk quota leased from other farmers (χ^2 =12.448, df=1, P<0.001), farm-related activities (χ^2 =25.207, df=3, P<0.001), non-farm related activities (χ^2 =46.621, df=2, P<0.001), experience in dairy farming (χ^2 =22.724, df=3, P<0.001), experience in current farm (χ^2 =10.862, df=3, P<0.05), experience in decision making in current farm (χ^2 =7.828, df=3, P=0.05) and previous off-farm experience (χ^2 =21.552, df=1, P<0.05). A significant association was also identified between sales to big national dairy firms and holding responsible positions with a non-farm business that farmers own (χ^2 =10.286, df=1, P<0.01) and farm allocation (χ^2 =4.571, df=1, P<0.05). No other significant associations were identified between the other marketing channels and any of the examined farm and farmer's characteristics. Through the Kruskal-Wallis non parametric one way ANOVA test a significant relationship was identified (Figure 2) between factors such as sales price (P<0.05), contractual obligations (P<0.05) and marketing channel selection.

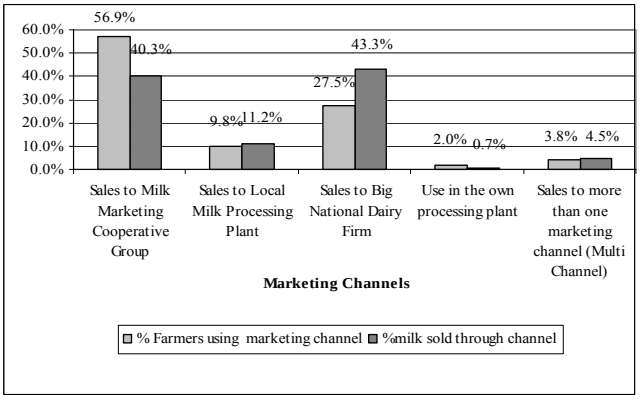

Figure 1: Marketing channel selection and utilisation

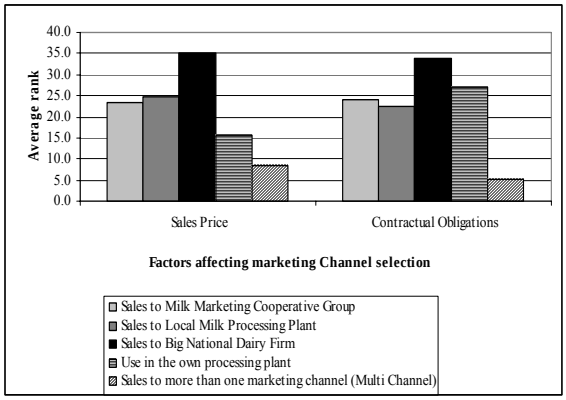

Figure 2: Factors affecting marketing channel choice

Conclusions The results of the present study demonstrate that sales price and contractual obligations influence the dairy cow farmers in Cornwall to adopt a particular marketing outlet. Also many farm/farmer's characteristics such as farm allocation and holding of responsible positions found to be related to the marketing channel selection by these farmers.

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The impact of farm/farmer's characteristics on marketing channel selection by sheep farmers in Cornwall in U.K

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Introduction Little is known about the strategic management process of farmers and particularly about the factors and the farmers' characteristics that influence them to choose a particular strategic alternative. Some studies have attempted to identify the characteristics of farmers using particular channels. Distribution risk and transaction cost are some factors that influcence marketing decision making (Royer 1995, Hobbs 1996). This paper examines which farm and farmer's characteristics affect the choice of marketing channel by sheep producers in the county of Cornwall in UK.

Materials and methods An eight page questionnaire was developed in a postal survey to be conducted aiming to identify the marketing channels that were used by farmers, the characteristics of their farms and the farmers themselves as well as the factors that influence them to adopt a particular marketing channel. The questionnaire was piloted in spring of 2003 in 26 sheep farmers operated in Cornwall. The main survey conducted in the summer of 2003 in a sample of 240 sheep farmers in the County of Cornwall in U.K. The effective response rate was 17.5%. The sample for the pilot survey was derived randomly from membership lists of the NFU South West Office while the main survey was conducted on other NFU members. Those lists included 266 sheep farmers operating in the County of Cornwall. The relationship between the factors affecting the choice of marketing channel and the selection of a particular marketing outlet, was assessed through the Kruskal-Wallis non parametric test. The one way chi-square analysis was employed to investigate the association between farm's and farmer's characteristics and the selection of each identified marketing channel.

Results The results of the survey identified five categories of marketing channels that are presented in Figure 1. The chi – square analysis indicated a significant association between direct sales to abattoir and characteristics such as holding responsible position in livestock marketing scheme (χ^2 =8.333, df=1, P<0.01), holding responsible position in farming organizations (χ^2 =8.333, df=1, P<0.01), distance from marketing channels (χ^2 =8.333, df=1, P<0.01) and previous off-farm experience (χ^2 =5.333, df=1, P<0.05). A significant association was also found between sales to more than one marketing channel and holding responsible positions in farming organizations (χ^2 =10.889, df=1, P<0.01), holding responsible position with a non-farm business that farmers own (χ^2 =14.222, df=1, P<0.001), farm income (χ^2 =6.333, df=1, P<0.05), financial performance (χ^2 =12.333, df=1, P<0.05), distance from marketing channels (χ^2 =14,222 df=1, P<0.001), livestock price (χ^2 =10.333, df=2, P<0.01), area leased from other farmers (χ^2 =12.333, df=2, P<0.01), livestock quota leased from other farmers (χ^2 =10.889, df=1, P<0.01), non farm related activities (χ^2 =16.333, df=2, P<0.001) and previous off farm experience (χ^2 =5.556, df=1, P<0.05). It was not identified any significant association between the rest marketing channels and any of the examined farm and farmers characteristics. Through the Kruskal-Wallis non parametric one way ANOVA test a significant relationship was found out (Figure 2) between factors such as access to more buyers (P<0.05), ability to withdraw sample (P<0.05), ease of parking and unloading vehicles (P<0.05) and marketing channel selection.

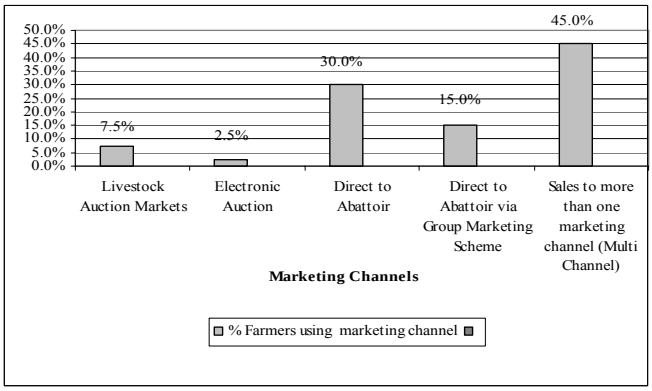

Figure 1: Marketing channel selection and utilisation

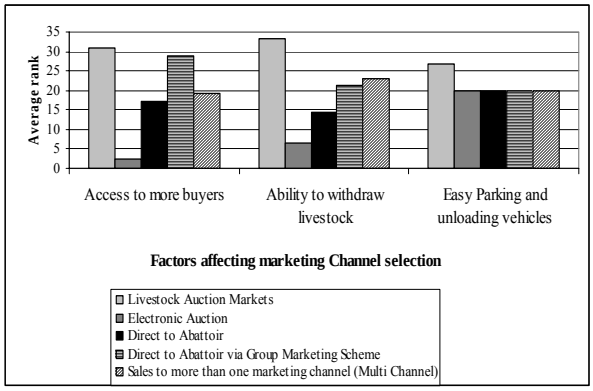

Figure 2: Factors affecting marketing channel choice

Conclusions The present study demonstrate that factors such as access to more buyers, ability of the farmer to withdraw his livestock and easy parking and unloading vehicles influence the sheep farmers in Cornwall to adopt a particular marketing outlet. Also many farm and farmer's characteristics such as distance from marketing channel, previous off farm experience, financial performance found to be related to the marketing channel selection by these farmers.

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The fatty acid profile of M. *Longissimus dorsi* from lambs fed oils or oilseeds rich in polyunsaturated fatty acids

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Introduction Sheep meat has an unfavourable ratio of polyunsaturated fatty acids (P) to saturated fatty acids (S) but feeding plant oils rich in P improved this ratio (Wachira et al., 2002). Due to ruminal biohydrogenation, the increase in muscle P is small relative to dietary supply. Some biohydrogenation is desirable since conjugated linoleic acid (CLA), considered to have human health promoting properties, is synthesised in the rumen by incomplete biohydrogenation of linoleic acid and in tissue by desaturation of ruminally derived trans-vaccenic acid (TVA). Controlling the rate of oil release to the rumen might increase the efficiency of transfer of dietary P to tissue while allowing the production of CLA. The objective of this study was to compare the effectiveness of linseed and camelina oil, and oil protection strategies, for increasing the CLA and n-3 P content of muscle.

Materials and Methods Sixty-six wether lambs blocked by initial bodyweight (40kg, s.d 4.69kg) were offered, for 100 days, one of six barley/beet pulp-based rations which differed in fat source: i.e. Megalac (ML), Camelina (C) oil (C18:2:C18:3 = 0.68, CO), Linseed (L) oil (C18:2:C18:3 = 0.47, LO), C seed treated with 10gNaOH/kg (CS), L treated with 5gNaOH/kg (LS) and CO treated with ethanolamine (CA).Growth was monitored fortnightly and allowances were adjusted to achieve similar carcass weights at the end of the experimental period. After slaughter, the carcasses were chilled for 48h at 4ºC. Intramuscular fat was extracted in duplicate from M. *longissimus dors*i, separated into the neutral and polar fraction using pre-packed SPE cartridges and then methylated. Fatty acid methyl esters (FAME) were analysed by gas-chromatography with a 100m CP-88 Sil column and the concentration of individual fatty acids in the muscle determined. Data were analysed according to a randomised block design using Genstat 6.0. "A priori" contrasts were also used to compare oils and NaOH treatment *per se*.

Results The fatty acid data are summarised in Table 1. For both lipid fractions, LS was most effective treatment in increasing the C18:3 and CLA concentration and decreasing the n-6:n-3 P ratio in muscle. Within C treatments, CA resulted in the highest C18:3 and lowest CLA concentration in muscle On average, oil resulted in lower C18:3 concentration and n-6:n-3 ratio and higher TVA concentration and than seeds. Compared to C, L increased C18:3 and CLA (polar lipid only) concentrations and decreased the n-6:n-3 P ratio.

Table 1 Concentration of fatty acids in *M. longissimus dorsi*

Treatment	ML	CO	LO	CS	LS	CA	s.e.d.	Sig	Oil	Seed	Sig	C	L	P
Neutral lipids (mg/100g muscle)														
C 18:2	78.36	98.06	88.61	87.88	85.70	98.90	10.89	NS	93.34	86.79	NS	92.97	87.16	NS
C 18:3	15.87^{a}	50.04^{b}	58.97^{bc}	53.98^{bc}	79.26^{d}	63.86^{c}	7.892	***	54.51	66.62	*	52.01	69.12	**
CLAc9t11	28.53^{a}	43.21^{bcd}	40.87^{abc}	48.08^{cd}	56.87^{d}	32.73^{ab}	7.291	**	42.04	52.48	*	45.65	48.87	NS
TVA	96.87^{a}	211.9^{c}	216.6^{c}	160.4^{b}	150.8^{b}	133.5^{ab}	25.52	***	214.3	155.6	**	186.2	183.7	NS
P:S Ratio	0.100^{a}	0.136^{b}	0.137^{b}	0.149^{bc}	0.166^{c}	0.138^{b}	0.009	***	0.14	0.16	**	0.14	0.15	NS
n-6:n-3 Ratio	4.50^{c}	1.93^{b}	1.64^{b}	1.80^{b}	1.10^{a}	1.57^{ab}	0.246	***	1.74	1.34	0.06	1.81	1.29	**
Total FA	3246	4377	3896	3773	3701	3897	375.5	NS	4137	3737	NS	4075	3799	NS
Polar lipids (mg/100g muscle)														
C 18:2	45.05^{b}	41.70^{ab}	42.27^{ab}	38.12^{a}	37.76^{a}	45.36^{b}	2.890	*	41.99	37.94	0.05	39.91	40.02	NS
C 18:3	2.50^{a}	10.81^{b}	17.49^{d}	14.44^{c}	23.87^{e}	17.22^{d}	1.339	***	14.15	19.16	***	12.63	20.68	***
CLAc9t11	0.81^{a}	0.95^{a}	1.29^{b}	1.50^{bc}	1.57^{c}	0.80^{a}	0.124	***	1.12	1.54	***	1.23	1.43	*
TVA	2.22^{a}	5.20^{c}	7.21^{d}	4.51^{bc}	4.33^{bc}	3.71^{b}	0.495	***	6.21	4.42	***	4.86	5.77	*
P:S Ratio	0.86^{a}	0.94^{ab}	1.03^{b}	0.97^{ab}	1.16^{c}	1.03^{b}	0.063	***	0.98	1.06	0.08	0.95	1.09	**
n-6:n-3 Ratio	6.96^{d}	2.78^{c}	2.01^{b}	2.03^{b}	1.27^{a}	2.15^{b}	0.248	***	2.32	1.55	**	2.34	1.54	**
Total FA	278.3	281.9	281.1	283.2	278.5	273.6	4.823	NS	281.5	280.9	NS	282.6	279.8	NS

ML, CO, LO, CS, LS, CA, C and L = megalac, camelina oil, linseed oil, camelina seed + NaOH, linseed + NaOH, camelina amide, camelina and linseed, respectively. Means with similar superscripts do not differ significantly.

Conclusions The higher CLA concentrations in muscle from lambs fed the high linolenic acid treatments confirms the role of tissue desaturation of TVA in CLA synthesis. Caustic treatment of oilseeds resulted in an improved fatty acid profile in the muscle compared to oil. Chemical protection was most effective in decreasing ruminal biohydrogenation of dietary P.

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In vivo prediction of carcass composition and muscularity in purebred Texel lambs

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Introduction Carcass conformation has been found to be associated with fatness among carcasses of similar weight and subjectively assessed fat cover (Kempster *et al*., 1981), leading these authors to suggest that assessments of conformation in live animals were even more likely to be confounded with fatness. Consequently, selection for improved shape would likely be opposed to the overall objective of reduced fatness in lamb carcasses. However, conformation remains a highly valued trait among lamb producers and breeders. In principle, shape can also be related to variation in lean: bone ratio and muscularity, defined as the depth of muscle relative to the skeletal dimension. The objectives of this work were to compare a live animal assessment of the conformation of the hind leg and ultrasonic measures of muscle and fat depths as predictors of carcass composition and muscularity.

Materials and methods 142 purebred Texel lambs were selected for slaughter from two flocks either selected for high lean tissue growth rate or leg conformation. Lambs were weaned at a mean age of nine weeks and reared indoors on an *ad-libitum* pelleted diet based on barley and dried grass. Live weights and ultrasonic muscle (UMD) and fat depth (UFD) were measured at the third lumbar vertebra at a mean age of 139 ± 4.7 days. A handling assessment of the shape of the hind-leg (LSC) was made using a nine-point scale (1= poor to 9=excellent shape). After slaughter, muscle depth (B) was measured on the cut surface of the *longissimus dorsi* (LD) muscle at the last rib and side length (SL) and leg length (T) were recorded. The carcasses were dissected into muscle, fat, bone and waste with individual weights recorded for the *longissimus dorsi*, *biceps femoris*, *rectus femoris* and *semimembranosus* muscles. Muscularity indices were calculated as UMD/body length (UMDL), B/SL (BSL), or from the weight of the LD muscle and side length (LDSL) or the weight of three leg muscles and femur length (3MFL) using the general formula $\sqrt{(\text{muscle weight/length}^3)}$. Stepwise regression procedures were used to evaluate the relationships between carcass traits and *in vivo* measures, retaining the fixed effects of flock and sex where significant ($P<0.05$). Correlations among traits were estimated from the residuals after fitting fixed effects for flock and sex.

Results Muscularity traits and LSC were not significantly ($P>0.05$) correlated with scan weight or UFD and tended to be negatively associated with fat proportion (Table 1). Low, positive correlations were observed between muscularity traits and UMD, lean proportion and lean: bone ratio. Correlations among muscularity traits were moderate (Table 2) and correlations between traits within regions tended to be higher than for traits measured in different locations. The correlation between LSC and 3MFL approached the value of the repeatability estimate of LSC (0.64 ± 0.07).

Table 1. Correlations of muscularity traits and composition

	UMDL	BSL	LDSL	3MFL	LSC
Scan weight	-0.05	-0.03	-0.08	0.09	-0.05
UMD	0.84	0.47	0.43	0.36	0.33
UFD	-0.03	-0.01	-0.01	-0.08	-0.04
Lean proportion	0.25	0.25	0.28	0.27	0.25
Fat proportion	-0.17	-0.18	-0.16	-0.12	-0.17
Lean: bone ratio	0.14	0.18	0.34	0.38	0.25

Table 2. Correlations among muscularity traits. ($P < 0.05$ for $r > 0.17$)

	UMDL	BSL	LDSL	3MFL
BSL	0.50			
LDSL	0.53	0.66		
3MFL	0.35	0.39	0.49	
LSC	0.36	0.37	0.39	0.57

Flock, sex, slaughter age and scan weight explained 0.78 of the variation in lean weight. The addition of LSC or UMD plus UFD increased the proportion of variation explained to 0.81 and 0.83 respectively, and to 0.84 when all three traits were included. A similar pattern was observed for the prediction of lean proportion, with an R^2 of 0.36 for prediction from scan weight, rising to 0.40, 0.53 and 0.54 with the addition of LSC or UMD plus UFD or a combination of all three traits respectively. LSC made marginal improvements to the prediction of fat proportions, with improved LSC being associated with reduced fatness. Flock explained 0.18 and 0.05 of the variation in LDSL and 3MFL respectively. For the prediction of LDSL, the addition of LSC or UMD increased R^2 to 0.30 or 0.32 and to 0.37 for LSC and UMD combined. For 3MFL, R^2 increased to 0.16 with the addition of UMD, 0.35 for LSC and 0.38 for LSC plus UMD.

Conclusions Visual assessments of leg shape in live Texel lambs represented a measure of muscularity that was largely independent of live weight and fatness and positively correlated with lean yield, proportion and lean: bone ratio. In the absence of ultrasonic measurements, leg shape score added to the accuracy of prediction of lean weight and proportion, but was of little additional value when ultrasonic measurements were available. Leg shape score and UMD were of similar value for the prediction of loin muscularity, but leg shape score was a superior predictor of leg muscularity.

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The effect of sex and dietary source of fat on cholesterol content in the *m. longissimus dorsi* of Polish Landrace fatteners.

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Introduction Human dietary science gives preference to animal products low in fat and rich in polyunsaturated fatty acids (PUFA), especially n-3 (Goodnight, 1993). Dietary n-3 PUFA decreased the level of cholesterol and its low-density lipoprotein fractions in blood serum (Ulbricht, 1992). The problem of how to decrease the cholesterol content of meat by way of nutrition is still unresolved. Full-fat flax seeds and linseed oil are particularly rich in n-3 PUFA. Our studies failed to show a clear effect of linseed on cholesterol content of fattening pig tissues (Barowicz et al., 1997). The aim of the studies was to determine the effect of Ca salts of fatty acids made partly from linseed oil (Erafet M), linseed oil and full-fat flax in diets for finishing fatteners on total cholesterol content in the *longissimus dorsi* muscle. Moreover, the influence of fatteners sex was also taken under consideration.

Materials and methods Three experiments were carried out on 120 Polish Landrace fatteners. Animals from 70 to 105-110 kg of body weight were feed ad-*libitum* with free access to the water. Complete feed was formulated according to Polish Feed Requirements containing 15.2% total protein, 2.27% crude fat, 12.44 MJ/kg metabolic energy, 0.9% lysine, 0.29% methionine, 0.18% tryptophan, 0.57% threonine and 0.83% calcium. The ingredients were wheat, barley, corn, soyabean and 3% premix. Experiment I– addition of calcium salts of linseed oil fatty acids (Erafet M) in amount of 8% of fodder fat ; in experiment II – 3% addition of linseed oil; in experiment III- 15% full-fat flax addition. Fat from 10 g of homogenised meat samples was extracted in a 2:1 mixture of chloroform and methanol (Folch et al., 1957). The content of cholesterol was determined in accordance of the procedure given by Rhee et all (1982) by spectrophotometer (Beckman DU 640, USA) at a wavelength of 570 nm. The data were analysed by analysis of variance. Data are presented as means ± SE.

Results Three different source of fat used in the study in fatteners' diets decreased the total cholesterol level in *longissimus dorsi muscle* (Tab. 1). Statistically significant differences were noted concerning the 15% addition of full-fat flax and 3% addition of linseed oil ($P<0.05$). In the last case (3% addition of linseed oil) the effect of fatteners' sex on total cholesterol level was observed in *longissimus dorsi muscle.* Studied samples of gilts' meat were characterised by lower total cholesterol level ($P<0.05$).

Table 1. The effect of the fatteners' sex and dietary source of fat on total cholesterol content (mg/100 g fresh tissue) in *longissimus dorsi* muscle.

Fatteners' sex	Fat source					
	Fodder fat (Erafet M) ($\overline{X}$ ±SE)		Linseed oil ($\overline{X}$ ±SE)		Full-fat flax ($\overline{X}$ ±SE)	
	0	8%	0	3%	0	15%
Castrates (n=10)	54.3±2.3	53.6±2.3	65.0±2.2	63.2±2.0	59.8±4.0	55.3±3.6
Gilts (n=10)	57.1±2.3	52.7±2.3	63.9±2.0[a]	57.6±2.4[b]	62.5±3.6	55.7±3.3
Total (n=20)	55.7±1.6	53.1±1.6	64.5±1.5[a]	60.4±1.6[b]	61.2±2.7[a]	55.5±2.4[b]

a, b –Means are significantly different at $P< 0.05$

Conclusion It is suggested that full-fat flax and linseed oil, especially their additions in amount respectively 15 and 3%, supplemented to complete mixture for finishing fatteners (from 60-70 to 105-110 kg b.w.) may be one of the ways of improving the dietary value of pork meat.

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Effects of a grass silage and concentrate diet on CLA levels in beef adipose tissue

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Introduction The nutritionally important fatty acid cis-9, trans-11 18:2 (conjugated linoleic acid, CLA) is formed from the major plant fatty acid cis-9, cis-12 18:2 in the rumen. An important intermediate in the biohydrogenation process is trans-11 18:1 (18:1 tr) and CLA is also synthesized from 18:1 tr in adipose tissue by the action of stearoyl CoA Δ-9 desaturase. Diet is known to affect CLA levels in meat (particularly adipose tissue) and this study examined the effects of a predominantly grass or concentrate diet fed to cattle and slaughtered at 3 ages.

Materials and methods 64 steers were used in the main part of the trial, half Aberdeen Angus cross (AA) and half Holstein Friesian (HF). From 6 months of age they were fed either perennial ryegrass silage (containing 0.15 sugar beet pulp) or concentrates (0.6 barley, 0.2 sugar beet pulp, 0.125 full-fat soya), so that both groups grew at a similar rate. They were slaughtered at 14 or 24 months of age. An additional 8 steers of each breed were reared to 14 months on the grass silage and from 14 to 19 months they were grazed on perennial ryegrass pasture. Subcutaneous adipose tissue from the loin region was removed at slaughter and fatty acids were extracted in chloroform and measured by GLC. The data were analysed by general analysis of variance with slaughter age, breed and diet as the main factors.

Results At 14 and 24 months, the concentrations of 18:1 tr, CLA and 18:2 n-6 were much higher in animals fed Concs (Table 1). 18:3 n-3 was higher in those fed grass silage. Most fatty acids were at similar concentrations at the two ages although 18:0 declined and CLA increased as the cattle got older. In the grazed steers at 19 months, concentrations of 18:1 tr and CLA were similar to the groups in the main trial fed Concs (Table 2). The relationship between CLA and 18:1 tr is shown in Figure 1.

Table1. Effects of diet and breed in steers aged 14 and 24 months (g/100g fatty acids)

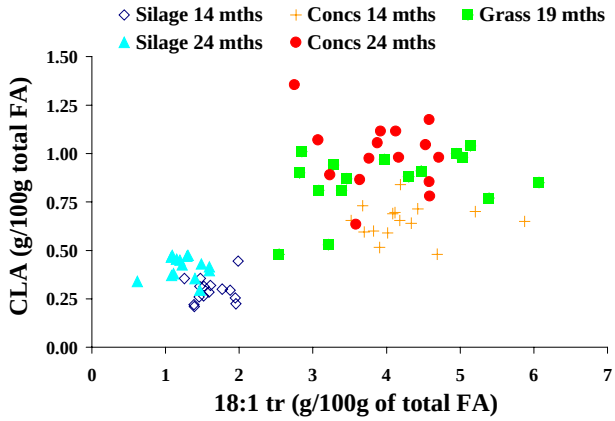
	Concs		Grass silage		sed	Sig.
	AA	HF	AA	HF		
14m						
18:0	17.7^{b}	17.5^{b}	14.3^{a}	15.3^{a}	1.33	*
18:1tr	4.5^{b}	4.7^{b}	1.7^{a}	1.9^{a}	0.29	***
18:2 n-6	1.8^{b}	2.5^{c}	0.8^{a}	0.9^{a}	0.14	***
18:3n-3	0.2^{a}	0.3^{b}	0.5^{c}	0.6^{d}	0.02	***
CLA	0.7^{b}	0.7^{b}	0.3^{a}	0.3^{a}	0.05	***
24m						
18:0	10.9^{a}	13.2^{b}	9.7^{a}	11.2^{ab}	1.11	*
18:1 tr	4.0^{b}	4.3^{b}	1.5^{a}	1.5^{a}	0.46	***
18:2 n-6	1.9^{b}	2.2^{b}	0.8^{a}	0.8^{a}	0.21	***
18:3 n-3	0.2^{a}	0.2^{a}	0.5^{b}	0.6^{b}	0.05	***
CLA	1.2^{b}	1.0^{b}	0.5^{a}	0.4^{a}	0.10	***

Means with different superscripts are SD (P<0.05). Main effects * P<0.05; *** P<0.001

Table 2 Effects of breed of steers grazing fresh pasture to 19 months (g/100g fatty acids)

	AA	HF	SED	Sig
18:0	13.7	16.7	1.92	NS
18:1 tr	4.1	4.5	0.58	NS
18:2 n-6	1.0	1.0	0.07	NS
18:3 n-3	0.7	0.7	0.05	NS
CLA	0.9	1.0	0.08	NS

Figure 1. Effect of age and diet upon relationship between adipose tissue CLA and 18:1 tr



Conclusions 18:1 tr and CLA were generally correlated in steers given different diets although both were lowest on grass silage. CLA increased relative to 18:1 tr as the steers got older, possibly reflecting an increasing enzyme activity in adipose tissue.

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Production of polyclonal antibody for norfloxacin detection using immunoassays (ELISA)

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Introduction The indiscriminate use of antibiotics to increase animal production may lead to residues in animal products, what justifies the monitoring of those chemicals (Heitzman, 1996). The intensification of livestock production in the world has been observed with an increasing use of drugs and growing promoter substances used as animal treatment or disease prevention. Several analytic techniques have been used to detect antibiotics residues of animal products such as fluorometry, liquid-gas chromatography, high performance liquid chromatography and immunological methods. The use of ELISA ("enzyme-linked-immunosorbent assays") combined to specific antibodies has been employed on routine clinic diagnosis, identifying and quantifying species and substances. In this study, the objective was the production of polyclonal antibody to detect the norfloxacin antibiotic by indirect ELISA method.

Material and methods Three female Norfolk rabbits were immunised each 15 days during six weeks (Duarte et al., 2002) with 50 μg norfloxacin molecule bound to bovine serum albumin (BSA) to produce polyclonal antibodies for norfloxacin detection. In the immunisation, blood samples were collected from the rabbit ear marginal vein, centrifuged and the sera were frozen. The sera were used for titillation with Plate Trapped Antigen (PTA-ELISA) (Crowther, 1995). The reactions were developed using alkaline phosphatase enzyme system. The O.D. measurement was realised at 405nm in Bio Rad mod. 550. All the data were done with three repetitions and analysed with Packard System Software.

Results One rabbit showed higher titre and it was chosen to be sanguinated. Different concentrations of the serum were tested (Figure 1) and 1/500 dilution had better titre (O.D. 405 nm). Similar results were obtained by Gobbo et al. (2003) working with the same group of antibiotics. In Figure 2, different concentrations of norfloxacin were used (5μg mL $^{-1}$ e 1μg mL $^{-1}$) and the curves showed determination coefficient close to 1 (R^2= 0,9985 for 5ug of norfloxacin and R^2=0,9893 for 1ug of norfloxacin). These values are satisfactory as an indicative for standardisation and quality control of this experiment (Van de Wiel & Koops, 1985).

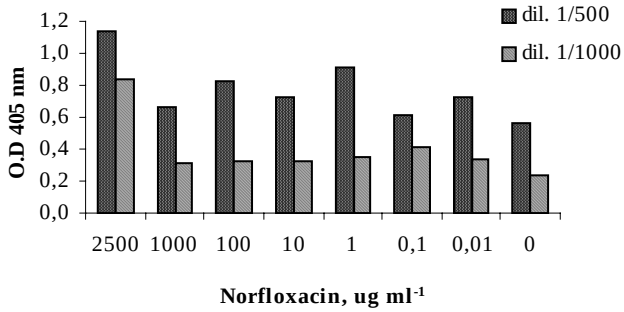

Figure 1. Norfloxacin quantification using polyclonal antibodies in different dilutions, as shown on legend

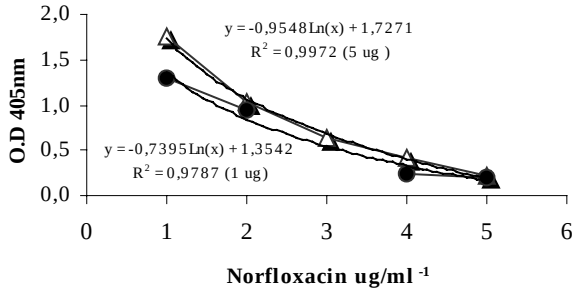

Figure 2. Linear regression of norfloxacin doses detected by polyclonal antibodies

Conclusion The partial results presented showed satisfactory titre for immunoassay utilisation to detect norfloxacin residues in livestock in Brazil. To validate this assay, new experiments have been conducted to reach the quality required by the European Community.

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Standardization of the immunoassays (ELISA) to detection of gentamicin in livestock using polyclonal antibody

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Introduction The intensification of cattle in the world and the use of veterinary substances as growing promoters in bovines, sheep, goats and poultry represent a large amount of the total cost of livestock production. Antimicrobial additives when used in animal production for long periods can accumulate residues in animal tissues, including the risk of interactions with other drugs. Global control and monitoring of the use of antibiotics in animal production are significant questions for public health due to the dissemination of microbial resistance to antibiotics drugs. In this study, the objective was to detect the gentamicin antibiotic by indirect PTA-ELISA method (plate trapped antigen. enzyme linked immunoassay), producing polyclonal antibodies from rabbits.

Material and methods One female New Zealand rabbit was used to produce the polyclonal antibodies in sequential immunization every 15 days for six weeks (Duarte et al., 2002) with 40µg gentamicin molecule bound with bovine serum albumin (BSA). In the immunization, blood samples were taken from the marginal vein of the rabbit ear, centrifuged and the sera stored at -20^{o}C until required. The sera were used for titillation through indirect test of ELISA ("enzyme-linked immunosorbent assay"), type "Plate Trapped Antigen" (PTA-ELISA) (Crowther, 1995). Horseradish peroxidase enzyme system was used to develop the reactions in the plate and the spectrum count was realized at 480nm in BioRad microplate reader mod. 550. The results with three repetitions were analysed with Packard System Software.

Results The study of the serum dilution is showed on Figure 1. There were not observed significant differences between the dilutions and the highest spectrum count were obtained when 1/200 serum dilution was applied. These results are similar than Ara et al. (1995) that developed a sandwich ELISA using high affinity monoclonal antibody to gentamicin. The test detected 0,1 µg/ml concentration and strong positive result in 0,2 - 0,3 µg/ml concentrations and there was not detected false positive when we tested against some aminoglycosids**.** Usually serum titre increase every new immunization, however, in this experiment the best serum titre was obtained from the serum collected on the third week (Figure 2). Probably, the reason for this result was the great animal variability that may decrease the titre due to immunology tolerance development.

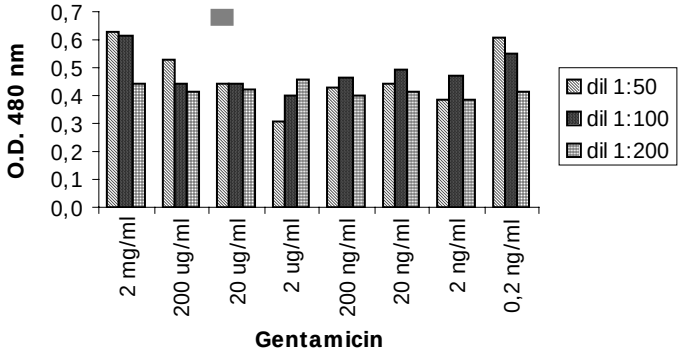

Figure 1. Curves of gentamicin quantification using polyclonal antibodies in different sera dilutions.

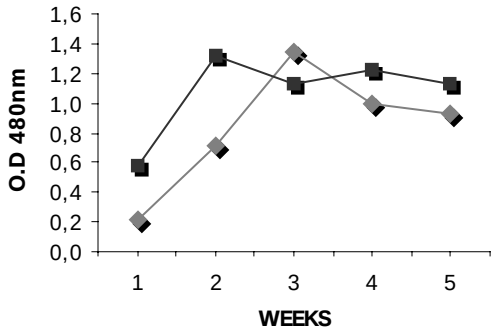

Figure 2. Curves of gentamicin doses (♦ - 0,2 mg mL^{-1}; 1 mg mL^{-1}) detected by polyclonal antibodies during the immunization schedule, with sera dilutions of 1:200.

Conclusion The results show that the antibodies showed satisfactory titre for immunoassay use. The partial results presented showed good titre to detect gentamicin residues using an immunoassay for Brazilian animal products. New studies are being conducted to validate this assay using meat and milk and also for other antibiotics.

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Effect of breed of slow-growing chickens on their meat quality

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Introduction In intensive poultry meat production, breeders have for many years tended to reduce the time of rearing broiler chickens. This coincides with an increasing growing number of those who oppose intensive production systems and with a growing interest in health food products among consumers in Western Europe. The results of many studies with birds kept in the Label Rouge system have shown the possibility of using slow-growing, local varieties of chickens in broiler chicken production (Kijowski, 2000; Laszczyk-Legendre, 1999; Peter et al., 1997). This study was therefore aimed to assess and compare the slow-growing native breeds of chickens (Rhode Island Red and Greenleg Partridge) for meat quality.

Material and methods The investigation carried out on 80 Rhode Island Red and 80 Greenleg Partridge chickens. Greenleg Partridge hen is a local Polish conserved breed, separated and the first time described in the end of XIX century. Its breeding books are kept since seventeen's of XX century. Chickens were reared to 14 weeks of age and were fed *ad libitum* with complete feeds for broiler chickens. At 14 weeks of age, 16 birds were selected from each genetic group for slaughter (8 cockerels and 8 pullets). 24-h cooling of carcasses at +4°C was followed by evaluation of some technological indicators of meat. Breast muscle and leg muscle pH was determined 24 h postmortem on the L*a*b* scale (Minolta CR310), drip loss after 24-h storage at +4°C, thermal losses during cooking, and maximum shear force of cooked breast muscles using Instron 5542 fitted with a Warner-Bratzler knife. The results were analysed statistically with analysis of variance and Duncan's multiple range test.

Results Higher pH_{24h} ($P<0.05$), lower drip loss ($P<0.05$) and lower thermal loss were characteristic of breast muscles of Greenleg Partridge chickens. Drip loss and thermal loss of leg muscles in birds of different origin did not show any statistical differences, with non-significant differences in pH_{24h}. Compared to breast muscles of Rhode Island Reds, those of Greenleg Partridges were characterized by darker colour and higher a* ($P<0.01$) and b* values. The effect of chicken breed on leg muscle quality was much smaller than on breast muscles, while the greatest, statistically significant differences concerned the colour. Just as breast muscles, leg muscles of Greenleg Partridges were darker, while greater saturation, especially towards yellow ($P<0.01$), was characteristic of leg muscles of Rhode Island Reds. Tenderness of breast muscles of the chickens, expressed as maximum shear force value, did not show any significant differences, although it assumed lower values among Greenleg Partridges.

Table 1 Results of muscle quality in 14-week-old Rhode Island Red and Greenleg Partridge chickens (x±SD).

Item	Breast muscles		Leg muscles	
	Rhode Island Red	Greenleg Partridge	Rhode Island Red	Greenleg Partridge
pH_{24h}	5.79^{b} ±0.03	5.91^{a} ±0.03	6.35±0.05	6.25±0.04
L*	62.89^{B} ±0.43	58.78^{A} ±0.50	47.31^{A} ±0.49	43.01^{B} ±0.62
a*	11.26^{A} ±0.27	13.47^{B} ±0.26	18.86±0.31	18.48±0.26
b*	12.02±0.53	12.68±0.32	8.61^{A} ±0.18	7.04^{B} ±0.18
Drip loss $_{24h}$ (%)	0.69^{b} ±0.07	0.42^{a} ±0.03	0.33±0.03	0.28±0.03
Thermal loss (%)	18.86±0.83	16.45±0.46	26.31±1.07	26.81±1.53
Shear force (N)	19.81±2.39	15.95±0.63	-	-

^{a,b} - $P<0.05$; ^{A,B} - $P<0.01$

Conclusions The study showed an effect of chicken breed on meat quality. More intensive colour, greater water holding capacity, more favourable pH and greater tenderness were characteristic of Greenleg Partridge breast muscles. The effect of chicken breed on meat quality was greater for white (breast) than for red (leg) muscles.
The assessment of selected meat quality traits indicates that the slow-growing native breeds of chickens can provide a valuable material for meat production.

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Total fat proportions and fatty acid profile in muscles of 42-day-old broiler chickens of different body weights

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Introduction Low fatness is one of the reasons why chicken meat is considered healthier than the meat of other farm animal species (Kijowski, 2000). Many research findings show, however, that the level and composition of fat in the body are subject to constant change, while the rate and direction of these changes are related to origin, sex, age and growth rate of the chickens (Komprda et al. 2000; Sütö et al., 1998). The results of studies available for the effect of body weight on meat quality of broiler chickens usually concern birds of different origin or those subjected to different length of the rearing period. The aim of the present experiment was to determine the effect of final body weight on crude fat percentage and fatty acid profile of breast and leg muscles of 42-day-old broiler chickens.

Material and methods ISA 215 chickens were reared to 42 days of age in standard environmental conditions and fed *ad libitum* with the same complete starter, grower and finisher diets. At 42 days of the experiment, 10 chickens were selected from each of the three weight groups: I – 1.5 kg, II – 2.0 kg and III – 2.5 kg. After slaughter and 24-h cooling of carcasses at +4^{o}C, samples of breast and leg muscles were taken to determine crude fat and profile of higher fatty acids C14:0, C16:0, C16:1, C18:0, C18:1, C18:2n-6, gC18:3n-6, C18:3n-3, CLA, C20:0, C20:4n-6, EPA (C20:5n-3), DHA (C22:6n-3). The level of crude fat was determined according to Soxhlet based on the Polish Standard PN-73/A-82111. Higher fatty acids were analysed with gas chromatography, while the proportions of individual acids were expressed in relation to the sum of all fatty acids determined. The results were analysed statistically with variance analysis and Duncan's multiple range test.

Results Body weight of 42-day-old chickens did not significantly affect the level of fat in muscles. The highest n-3 and n-6 PUFA was characteristic of muscles of 2.0 kg chickens, with a tendency towards narrower n-6/n-3 PUFA ratio in heavier birds. The highest proportions of saturated fatty acids C14:0 and C16:0 was found in breast and leg muscles of 1.5 kg chickens. Compared to breast muscles, the more fatty leg muscles were characterized by lower SFA and higher UFA content. Fat of leg muscles showed a more beneficial UFA to SFA ratio, while a more favourable n-6/n-3 PUFA ratio was found in breast muscles.

Table 1 Fat proportions and fatty acid profile in muscles of 42-day-old ISA 215 chickens (x±SD).

Item	Breast muscles			Leg muscles		
	I	II	III	I	II	III
Crude fat (%)	0.96±0.11	0.95±0.11	0.98±0.18	3.57±0.17	3.45±0.25	3.64±0.28
SFA	40.33^{A} ±1.91	39.18±1.65	39.67^{a} ±2.41	37.72^{B} ±1.13	37.69±1.17	37.55^{b} ±1.61
UFA	59.67^{A} ±1.91	60.82±1.65	60.33^{a} ±2.41	62.28^{B} ±1.13	62.31±1.17	62.45^{b} ±1.61
MUFA	40.49^{A} ±2.99	40.07^{A} ±2.80	40.42^{A} ±2.99	46.70^{B} ±1.98	45.93^{B} ±1.40	46.35^{B} ±1.14
PUFA	19.18^{A} ±2.90	20.75^{A} ±2.92	19.91^{A} ±1.24	15.58^{B} ±2.11	16.38^{B} ±2.26	16.10^{B} ±1.35
PUFA n-6	17.33^{A} ±2.69	18.64^{A} ±2.63	17.83^{A} ±1.09	14.12^{B} ±1.94	14.77^{B} ±2.04	14.57^{B} ±1.20
PUFA n-3	1.63^{Aa} ±0.23	1.90^{Ab} ±0.36	1.83^{A} ±0.27	1.19^{B} ±0.16	1.21^{B} ±0.17	1.22^{B} ±0.15

^{a,b} - P<0.05; ^{A,B} - P<0.01

Conclusions Differences in the body weight of 42-day-old broiler chickens did not affect muscle fatness. From a consumer viewpoint, breast muscles of 2.0 kg chickens were characterized by the most desirable composition of fat. The highest level of hypercholesterolemic saturated fatty acids was found in the muscles of the slowest-growing 1.5 kg birds. Breast and leg muscles of the chickens differed not only in the level of crude fat, but also in the profile of higher fatty acids.

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Intake and digestibility of tanniniferous browse species fed to sheep in three different levels of protein supply

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Introduction Legume trees are potential sources of protein, vitamins and minerals. However, the presence of tannins may limit the utilization of many leguminous fodder trees and shrubs. The aim of this work was to investigate intake and apparent digestibility of three legume plants fed to sheep in iso-nitrogenous diets with three levels of crude protein (CP) supply.

Material and methods Three iso-nitrogenous feeding trials providing 12, 16 and 20 g N per day were conducted to determine the effects of increasing levels of tannins in browse on dry matter (DM) intake, DM and CP apparent digestibilities. Sheep were kept in metabolic cages allowing 7 days for adaptation and 7 days for data collection. There was one experimental period for each N intake level. Three mature sheep (35-40 kg LW) were allocated to each of the four treatments: coast cross hay supplemented with soybean meal (control), leucaena (*Leucaena leucocephala*), cajanus (*Cajanus cajan*) or sesbania (*Sesbania sesban*), in a complete randomised design. Diets were offered *ad libitum* twice a day (8:00 a.m. and 4:00 p.m.) and refusals were collected at the following morning. During the collection period, offered and refused feeds and faecal and urine outputs were recorded daily. Urine was collected over 100 ml of sulphuric acid (10%). Daily refusals and faecal and urinary outputs were bulked for each animal and 10% of these samples were kept for analysis. Analysis of variance was carried out using the General Linear Model procedure (SAS, 2000). The means for treatment factors were compared by Tukey test (SAS, 2000).

Results Chemical composition of diets is presented on Table 1. The results for DM intake and apparent digestibility are shown on Table 2. The inclusion of sesbania, in the three groups of animals on 12, 16 and 20 g N per day, depressed DM intake. The low tannin content of cajanus resulted in similar intakes than the control diet for levels of 12 and 20 g N per day. However, leucaena, with condensed tannin levels similar to sesbania, resulted in significantly higher intakes than sesbania. For groups offered 12 and 16 g N, the apparent DM digestibility was lower for sesbania and leucaena relative to the control diet. For the group on 20 g N there were no differences in the DM digestibility. However, the mean standard deviations were rather large for this treatment and might indicate that animals differed widely in their adaptation to these diets. In comparison to the control, the protein digestibility was lower for all legumes. There were no differences ($P>0.05$) between treatments for N balance within protein levels of 16 or 20 g N per day (-2.35, 0.09, -0.66, -2.06 and -0.96, -4.17, -3.04, -5.84 respectively for diets control, cajanus, leucaena and sesbania). Only for the lower protein level (12 g N per day), diet sesbania presented significant ($P<0.05$) lower N balance (-3.61 g/d) compared to other treatments (0.31, -0.33 and 0.49 g/d, respectively for diets control, cajanus and leucaena).

Table 1 Chemical composition of tested feeds

Constituents[†]	*feeds*				
	coast cross hay	*cajanus*	*leucaena*	*sesbania*	*soybean meal*
DM	885	900	867	885	893
Ash	64	77	53	46	65
EE	24	36	33	29	8
NDF	814	699	582	721	52
ADF	461	569	432	556	161
CP	47	170	153	153	506
TP	0.60	0.82	2.57	2.87	-
TT	0.42	0.50	2.16	2.43	-
CT	0.02	0.05	1.27	2.23	-

[†] DM: dry matter (g/kg); Ash (g/kg DM); EE: ether extract (g/kg DM); NDF: neutral-detergent fibre (g/kg DM); ADF: acid-detergent fibre (g/kg DM); CP: crude protein (g/kg DM); TP: total phenolics (mg% TA); TT: total tannins (mg% TA); CT: condensed tannins (mg% catechin)

Table 2 Dry matter intake (DMI) and dry matter and crude protein apparent digestibility (DMD and CPD) of tested diets

parameters[†]	*diets*			
	control	*cajanus*	*leucaena*	*sesbania*
12 g N/day				
DMI	532 [ab]	427 [b]	588 [a]	235 [c]
DMD	517 [a]	467 [ab]	419 [b]	417 [b]
CPD	723 [a]	571 [b]	480 [c]	316 [d]
16 g N/day				
DMI	639 [a]	445 [b]	676 [a]	216 [c]
DMD	530 [a]	420 [ab]	364 [b]	318 [b]
CPD	783 [a]	635 [bc]	497 [c]	670 [ab]
20 g N/day				
DMI	547 [a]	552 [ab]	777 [a]	163 [c]
DMD	509 [a]	495 [a]	328 [a]	262 [a]
CPD	804 [a]	581 [b]	473 [c]	321 [d]

[†] DMI, in g/d; DMD and CPD, in g/kg;
[a, b, c, d] means with different superscripts, within row, are significant different (Tukey test; $P<0.05$)

Conclusions Tannin levels *per se* are therefore unlikely to predict animal responses. As long as the diet provided a sufficient amount of protein, the tannins in the three treatments were not directly toxic to sheep. It would appear that the problems associated with browse feeding were not only due to tannins. Other factors such as inherently poor digestibility and low energy intake may have lead to poor animal performance.

Acknowledgements This experiment is supported by IAEA. Project number: 10267/RB

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Effect of tannin–rich sorghum grain on apparent digestibility and N utilization in lambs

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Introduction The presence of condensed tannins (CT) in sorghum grain can limit its use as animal feed. High proportions of tannin-rich sorghum grains in diets may affect intake and digestibility, resulting in low animal performance. Microbial fermentation is able to neutralise these effects and some tannins molecules are degradable in the rumen (Selinger et al., 1996). Other studies indicated positive effects on nutrient absorption and disease control when sheep are fed diets with low concentrations of CT (Aerts et al., 1999). High concentrate diets are commonly used for finishing lambs and sorghum grain is an important source, thus the observation on tannins effect in these diets are important to evaluate possible advantages or negatives effects on the use of tannin-rich sorghum hybrids. The aim of this work was to study the effects of tannin-rich sorghum grain in high concentrated diets for finishing lambs.

Material and methods Six male sheep averaging 56 kg live weight were randomly distributed in a double 3x3 Latin Square. Three experimental diets with different sorghum hybrids H0, H1 and H2 (Table 1) were offered at 8:30 a.m. and 16:30 p.m. during 45 days. Hybrids presented 0, 1.8 and 2.7% CT (DM basis) respectively for hybrids H0, H1 and H2. Condensed tannins were measured by butanol-HCl colorimetric assay (Porter et al., 1986). The animals were allocated in metabolic cages and experimental periods were designed for 10 days of diet adaptation and 5 days for samples collections. DM intake, total faeces and total urine were daily measured and collected and DM, crude protein (CP) and neutral detergent fibre (NDF) were determined. Total nitrogen was determined in faeces and urine. Analysis of variance was conduced using ANOVA procedure of SAS (SAS, 2000). Difference in means values between treatments were tested using Tukey test ($P<0.05$).

Results Apparent digestibilities of DM, CP and NDF, as well as nitrogen balance (NB) are shown in Table 2. Voluntary intake was not influenced by sorghum hybrids ($P>0.05$). Diet H0, without CT, presented the highest apparent digestibility for both DM and CP ($P<0.05$) Despite diets H1 and H2 had higher CT concentration, they met the requirements for finishing lambs. Animals fed H0 diet had higher N utilization ($P<0.05$). High NDF digestibilities were attributed to the low forage content in the experimental diets (20%DM). Tannin effect on NDF apparent digestibility was not clear.

Table 1 *Experimental diets*

Ingredients/Diets	*H0[1] (g/kgDM)*	*H1[1] (g/kgDM)*	*H2[1] (g/kgDM)*
Hay	200	200	200
Sorghum	730	690	700
Soybean meal	50	90	80
Mineral mixture	20	20	20
CP (g/kgDM)	120	120	120
ME (MJ)	2.57	2.58	2.58
Condensed Tannins (%)	0	1.30	1.70

[1] – H0, H1 and H2 are experimental diets with different types of sorghum hybrids

Table 2 *Dry matter voluntary intake, apparent digestibility of dry matter (DMD), crude protein (CPD) and neutral detergent fibre (NDFD) and nitrogen balance (NB) for sheep fed diets with different types of sorghum hybrids.*

Diets/Parameters	*Intake (g/day)*	*DMD*	*CPD*	*NDFD*	*NB*
H0[1]	1449	788[a]	633[a]	692[a]	14.55[a]
H1[1]	1430	722[b]	535[b]	582[b]	9.48[b]
H2[1]	1445	747[b]	530[b]	641[ab]	8.38[b]
P>F[2]	0.9644	0.0325	0.0094	0.0041	0.0051
CV[3](%)	9.1	4.7	10.8	6.2	20.9

[1] H0, H1 and H2 are experimental diets with different types of sorghum hybrids
[2] P<F significance probability
[3] Coefficient of Variance

Conclusions Tannin-free diet based on sorghum hybrids resulted in an increase of the digestive performance. Results obtained for tannin-rich hybrids are adequate for finishing lambs but promoted a decrease in nitrogen utilization.

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Calcium metabolism in sheep fed different calcium sources. 1. True availability

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Introduction Mineral deficiencies represent an important factor responsible for the low ruminant productivity in Brazil, and cause a decrease in growth rate and weight gain, low reproductive efficiency and low meat and milk production. Calcium is one of the minerals most studied in animal nutrition due to its great number of functions in animal metabolism. It is located in soft tissues and mainly in bones. Citrus pulp, Lucerne hay, limestone, oyster shell meal and dicalcium phosphate have been studied as low cost alternative Ca sources. Using the isotopic dilution technique, it is possible to obtain the true availability for this mineral. The aim of this experiment was to study the effect of different Ca sources on true Ca availability in sheep.

Material and methods Twenty Santa Ines (Brazilian breed) male sheep were used in a random design. Treatments were composed by a basal diet and one of the Ca sources (CP: citrus pulp, LH: Lucerne hay, LI: limestone, OS: oyster shell meal and DP: dicalcium phosphate. The basal diet was composed by maize grain, soybean meal, urea, mineral mixture, hydrolysed sugarcane bagasse and mono-ammonium phosphate. Treatments were calculated to meet the requirements for finishing lambs (NRC, 1985), on dry matter basis, and offered al level of 4.3% LW. Before assay, all animals were weighted, treated with anthelmintic and distributed into five stalls (four animals each treatment). After 21 days adaptation period, animals were weighted and allocated in individual metabolic cages. After adaptation to the metabolic cages (7 days), 7.7 MBq of ^{45}Ca were injected via right jugular vein. Blood samples were taken after 5 min, 1, 2, 4, 6 h after injection and then after each 24 h during 7 days. Urine and faeces samples were taken each 24 h during 7 days after ^{45}Ca injection. Ca specific activity in plasma and faeces, endogenous Ca and net and true absorption were estimate (Vitti 1998). Means were compared by analysis of variance and Student t test.

Results Plasma Ca content for the five treatments was according in the normal range (9-11mg/dl ,NRC,1985). There was no difference for live weight between groups (P>0.05). Despite differences have been observed for DM intake, Ca intake was not affected, remaining above 0.51% (DM basis) as recommended by NRC (1985). Diets CP, LH and OS promoted higher excretion of Ca in faeces than diet LI (P<0.05), but animals fed diets LI and DP presented similar Ca excretions (P>0.05). Diet CP presented higher endogenous losses (91.76 mg/kg $LW^{0.75}$) than diets LH and DP (55.47 and 52.15 mg/kg $LW^{0.75}$), but endogenous losses for diets LI and OS (80.57 and 61.67 mg/kg $LW^{0.75}$) were similar. Animals fed LI had highest Ca absorption and true availability. Urine Ca for the five treatments was similar to those presented in literature (<8mg/dkgLW- Braithwaite,1979)). Animals fed LI showed highest Ca retention compared to OS, CP and LH, but results were similar to DP.

Table 1 Effect of different calcium sources on calcium metabolism in sheep

Parameters	*Treatments*[*]					*sed*[**]
	CP	*LH*	*LI*	*OS*	*DP*	
Ca in plasma (%)	12.18^{a}	10.08^{b}	10.73^{ab}	9.98^{b}	9.33^{b}	0.802
Live weight (kg)	31.9^{a}	32.9^{a}	31.3^{a}	30.8^{a}	31.6^{a}	4.46
DM intake (g/kg $LW^{0.75}$)	92.63^{a}	84.65^{abc}	70.13^{bc}	85.60^{ab}	68.32^{c}	8.044
Total Ca intake (g/kg $LW^{0.75}$)	0.495^{ab}	0.469^{ab}	0.399^{b}	0.516^{a}	0.460^{ab}	0.0484
Total Ca in faeces (g/kg $LW^{0.75}$)	0.485^{a}	0.467^{a}	0.231^{c}	0.421^{ab}	0.337^{bc}	0.0497
Endogenous Ca in faeces (mg/kg $LW^{0.75}$)	91.76^{a}	55.47^{b}	80.57^{ab}	61.67^{ab}	52.15^{b}	15.826
Ca net absorption (mg/kg $LW^{0.75}$)	101.61^{cd}	58.15^{d}	248.56^{a}	155.90^{bc}	175.59^{b}	29.366
Ca true availability (%)	20.50^{cd}	12.48^{d}	62.09^{a}	30.28^{bc}	39.65^{b}	5.426
Total Ca in urine (mg/kg $LW^{0.75}$)	7.43^{a}	2.40^{a}	4.24^{a}	5.26^{a}	9.82^{a}	5.318
Ca retention (mg/kg $LW^{0.75}$)	2.27^{c}	0.02^{c}	163.90^{a}	88.92^{b}	113.41^{ab}	36.593

[*] Treatments: basal diet + citrus pulp (CP) or Lucerne hay (LH) or limestone (LI) or oyster shell meal (OS) or dicalcium phosphate (DP); [**] sed: standard error of difference between means
[a, b, c, d] means with different superscripts, within rows, are significantly different (P < 0.05)

Conclusions Limestone was the best Ca source among all tested sources. Organic sources (citrus pulp and Lucerne hay) presented lowest Ca absorption, availability and retention.

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Calcium metabolism in sheep fed different calcium sources. 2. A kinetic model

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Introduction With the use of radioactive calcium (Ca) it is possible to study the kinetic aspects of Ca metabolism. Research in Brazil has been carried out to study mineral metabolism in sheep and cattle, especially phosphorus, by using isotope dilution techniques. However, there is very little information on Ca metabolism in sheep. The objective of this experiment was to study the effects of various Ca sources on the Ca metabolism in sheep by using isotope and balance techniques.

Material and methods Twelve Brazilian male sheep received for 28 days a basic diet supplemented with different sources of Ca: limestone (LM), alfafa hay (AH), dicalcium phosphate (DF), shell meal (SM) and citrus pulp (CP). After a 21 d in the treatments,each animal was intravenously injected with 7.4.MBq of radio-calcium (Ca-45). Blood samples, feces and urine were taken at 24-h intervals for 7 days. Total Ca and radioactivity in all the samples were measured. After the end of collection period tissues samples were taken (liver, heart, kidney, muscles and 12th rib) for analysis. Model inputs experimentally measured and model output, applied to individual sheep, were statistically analyzed as a completely randomized design. A comparison of means was carried out using the GLMP (SAS, 1991). Treatment means were assessed for significant differences at $P<0.05$. The whole body P metabolism model by Vitti *et al*. (2000) was adopted to represent Ca flows in sheep.

Results Calcium true absorption values were 3.36, 0.78, 2.34, 2.06 and 1.28 g/d and true availability was 64.31, 12.38, 35.21, 32.17 and 20.07 %, respectively for LM, AH, DF. SM and CP ($P<0.01$). Ca from inorganic sources produced higher availability and absorption than hay and citrus pulp (organic Ca sources). The total Ca excreted in faeces (F_{01}) was affected by treatments ($P<0.05$) and lower values were observed for animals fed limestone. There were no significant differences in losses of Ca in urine (F_{02}) between the treatments. Total Ca absorption (F_{21}) and Ca flow from the central pool to gut (F_{12}) were higher for LM ($P<0.05$). Ca flux from blood to soft tissue (F_{42}) was not significantly different for the treatments. Ca recycling from tissue to the blood pool (F_{24}) was affected by Ca source ($P<0.01$). Ca recycling from blood to bone (F_{32}) showed no differences between treatments but the flow of Ca from blood to tissues (F_{23}) was higher for DF and SM.

Table 1 Comparison of inputs and outputs (g/day) for the different Ca sources in sheep

		Treatments					SEM
		LM	AH	DF	SM	CP	
Input fluxes							
Intake	F_{10}	5.20	6.20	6.77	6.26	6.32	0.88
Faeces	F_{01}	2.87^{a}	6.24^{b}	5.20^{b}	5.03^{b}	6.26^{b}	0.70
Urine	F_{02}	0.06	0.04	0.15	0.08	0.12	0.06
Model output							
Blood Ca to gut	F_{12}	3.18^{a}	0.93^{b}	1.24^{b}	1.25^{b}	1.48^{b}	0.56
Ca absorption	F_{21}	5.50^{a}	0.90^{b}	2.81^{b}	2.49^{b}	1.55^{b}	0.88
Blood Ca to bone	F_{32}	-0.0034	-0.0049	-0.0041	-0.0037	-0.0038	0.003
Blood Ca to tissue	F_{42}	-0.21	-0.41	-0.43	-0.23	-0.37	0.08
Tissue Ca to blood	F_{24}	-2.63^{a}	-0.39^{b}	-2.26^{a}	-1.80^{a}	-0.33^{b}	0.46
Bone Ca to blood	F_{23}	0.15^{ab}	0.05^{b}	0.40^{a}	0.41^{a}	0.02^{b}	0.08

$^{a, b}$ Mean values with unlike superscript letters were significantly different.

Conclusions The chemical form of the calcium present in the different sources affected calcium metabolism. Inorganic sources had higher availability values and higher Ca absorption. Negative values (F_{32}, F_{42}, F_{24}) observed in the present experiment might indicate that the animals need more Ca. The kinetics model could be used to illustrate the different processes that occur in sheep fed various Ca sources.

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Assimilation of phytin by ruminants

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Introduction It has long been known that a large part of organic phosphorus of cereals which are the principal constituents of concentrate mixtures usually fed to ruminants occurs in the form of phytic acid (inositolhexaphosphoric acid) or phytin (salt of phytic acid). It is also well known that in ruminants hydrolysis of dietary phytate occurs by action of phytase produced by rumen microorganisms, which renders phosphorus completely available for these animals. However some authors found that availability of phosphorus in phytate may be affected by other dietary constituents or by some features of the diet. The aim of this study was to study assimilation of phytate by ruminants and to ascertain if this form of phosphorus can be used as a good source of this mineral for ruminants.

Materials and methods The study was carried out with sixteen Brazilian breed male sheep, housed indoors in metabolism cages, receiving hydrolyzed sugarcane bagasse and a basic diet supplemented with limestone, Lucerne hay, citrus pulp and oyster shell meal (T_1, T_2, T_3 and T_4 respectively) (Table 1) during twenty-one days. The basic diet was composed of corn, soya bean and mineral mixture. After 21days of adaptation to the diets, feces and urine were collected every 24 hours for 7 days and analyzed for total phosphorus and phytate. Total phosphorus was determined using vanadate-molibdate reagents (Sarruge and Haag, 1974) and the method of Latta and Eskin was used (Latta & Eskin, 1980) for determination of phytate present in treatments and faeces. Experimental measurements were analyzed as a completely randomized design and General Linear Models Procedure (SAS, 1991) was used for comparison of means.

Results The average P intake was 99.3, 128.4, 132.1, 141.1 mg/kg LW/d for T_1, T_2, T_3 e T_4 respectively ($P<0.05$). The total dry matter ingested was: 24.5, 38.8, 35.3 and 32.7 g/kg LW/d respectively for T_1, T_2, T_3 e T_4 ($P<0.01$). Phytate excreted in fecaes had a linear relationship with phytate ingested: $y = 0.1713x + 216.13$ ($n=16$, $r^2 = 0.60$, $P<0.01$). The excretion of phytate through faeces occurred likely because phytase activity was incomplete or occurred at a site beyond where phosphorus is absorbed. Hydrolyzed sugarcane bagasse present in all treatments has high levels of phenolic compounds, which could have lowered the efficiency of phytase enzyme. Because the animals in the experiment refused to eat the hydrolyzed sugarcane bagasse, this feed was chopped increasing the passage rate of this feed what could also impaired complete phytase action. This hypothesis is in according with Reid et al. (1947), which suggested that finer particles of bran may pass from the rumen before complete hydrolysis of phytin could take place.

Table 1 Chemical composition of ingredients*

Ingredients	Ash	P	NDF	ADF
	%MS			
Soya bean	6.63	0.73	19.11	12.19
Corn	1.78	0.25	47.67	4.55
H.s. bagasse	6.97	0.05	58.85	54.35
Limestone	99.44	0.01	-	-
Lucerne hay	8.46	0.39	40.92	29.47
Citrus pulp	6.54	0.12	23.78	28.86
Oyster shell meal	97.50	0.05	-	-

* P= phosphorus, NDF= neutral detergent fibre, ADF= acid detergent fibre

Table 2: Means of variables: Phytate intake (mg/kg LW/day), phytate excreted in faeces (mg/kg LW/d), Percentage of phytate excreted.

Phytate	T_1	T_2	T_3	T_4	S.E.M.
Intake	338.1^{b}	478.2^{a}	363.2^{b}	439.3^{ab}	25.28
Excreted	78.7^{b}	144.9^{a}	98.1^{ab}	115.0^{ab}	13.00
Percentage	23.20	30.43	26.58	26.58	

$^{a, b}$ Mean values with unlike superscript letters were significantly different $P < 0.01$.

Conclusions The results show that phosphorus present in form of phytate was not completely available for the animals used in this work. As the animals received an amount of phosphorus suitable to meet their requirements and a large amount of phosphorus was in the phytate form it is likely that some features of feed affected phytase enzyme reducing phosphorus absorption. The impact of feeding hydrolyzed sugarcane bagasse associated with a high phytate diet on phosphorus absorption in ruminants needs further research.

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Effect of monensin supplementation on high concentrate: forage ratio on Ghezel Lamb performance

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Introduction In some part of world for intensive production of fattening of lambs, they are fed with high amount of concentrate. However this pattern of feeding often affect negatively of rumen fermentation (Mould *et al* 1983). Ionophores act by interrupting transmembrane movement and intracellular equilibrium of ions in certain classes of bacteria and protozoa that inhibit the gastro intestinal tract (McGuffey et al 2001).The ionophore monensin can improve cellulose digestion of diets high in readily available carbohydrate by inhibition the growth of lactate-producing bacteria (Russell and Stroble 1989). An alternative method to reduce these negative effects could be the using step-up feeding by supplementation of monensin. The objective of this study was to obtain information on animal performance receiving diets high concentrate: forage ratio with different level of monensin.

Materials and Methods A total twenty wether Ghezel lambs (mean liveweight 24.5 ± 4.9 kg) were individually housed, and randomly assigned to one of 5 groups in a completely randomised design. The experiment was carried out over 12 weeks. They were initially fed a diet containing 55:45 concentrate to forage for 3 weeks. Alfalfa hay was used as forage and concentrate was based on soybean meal, cracked barley and vitamin and mineral supplement. This ratio was fixed for control group till end of experiment. After three week of adaptation and acclimatisation period, groups 1-4 were feed a diets supplemented with four level of monensin (0, 10, 20 and 30 mg /kg DM). The concentrate to forage ratio in these groups was increased weekly by 5%. Group 5 consumed constant C: F ratio (45: 55 with no added monensin). The diets were offered ad libitum to all animals 2 times a day with free access to water and salt. Daily food intake for individual lamb was estimated from difference between food offered and refusals. The live weights of lambs were recorded on day 1 in each weeks of 12 week of study before morning feeding. Blood samples were collected from 4 lambs in each treatment by jugular venipuncture into an hepararinized evacuated tube 4 hours after morning feeding at the start and last week of experiment. The plasma was assayed for urea and glucose. Data were subjected to analysis of variance using the GLM procedure of statistical analysis system institute (SAS, 2000). Effects of the treatments were tested using animal within period × treatment as the error term.

Results The results of the statistical analysis of the DMI, BWG, FCR and blood glucose and urea are presented in the table 1. Supplementation of diets containg high amount of concentrate with monensin significantly decreased feed intake ($p<0.05$). As expected significantly difference in BWG and FCR were obtained by step-up feeding especially by using 30 mg/kg DM monensin. There was a non significant trend to suggest a dose related response in the blood plasma glucose to increasing monensin in the step-up diets (table 1) no significant changes in the glucose and urea in the blood plasma. There were no treatment effects on plasma urea concentration.

Table 1 Effect of monensin on lamb's performance and blood metabolites when using high level of C: F ratio at the end of study.

Treatment	Control	Step-up diets				SEM
		Monensin (mg/kg DM)				
		0.0	10	20	30	
DMI (kg)	52.4[a]	49.5[a b]	46.9[bc]	45.9[bc]	45.0[c]	2.47
BWG (kg)	6.93[c]	7.12[bc]	7.20[b]	7.30[b]	7.52[a]	0.14
FCR	7.47[c]	6.60[bc]	6.30[b]	6.25[b]	5.93[a]	0.14
Glucose (mg/dL)	38.48[a]	39.82[a]	41.15[a]	42.35[a]	44.02[a]	2.84
Urea (mg/dL)	17.39[a]	20.69[a]	16.45[a]	15.00[a]	14.00[a]	3.42

[a,b,c]: means in row with different superscripts differ significantly ($P<0.05$).

Conclusion The results obtained in this experiment indicated that of inclusion of high level of concentrate supplemented by monensin in the complete diets had improved animal performance and did not affected on the blood metabolites. The FCR was minimised by adding monensin at 30 mg/kg DM.

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The effects of different levels of sulphur and pyridoxine on the microbial protein synthesis of Ghezel male lambs: 1. *in vitro*

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Introduction An understanding of amount of the sulphur and pyridoxine required for growth of ruminal bacteria is of importance for optimizing ruminal microbial protein and total sulphure amino acids synthesis. Whereas the results of some experiments indicate that sulphur and water soluble B vitamin stimulate growth of rumen bacteria *in vitro* condition. For example, Cho *et al.* (1988) reported average microbial protein yields were 35.14, 37.67, 36.02 and 36.07 mg/100ml, respectively, with control, and N:S ratio of 10:1, 15:1 and 20:1, and higher in rumen fluid containing S than the control. The objective of this experiment was to determine the effect of different level of S and B_6 on ruminal microbial protein synthesis.

Materials and methods Rumen fluid was taken from two fistulated male Ghezel lambs (50±4.5 kg BW). The rumen fluid was collected before the morning meal and strained four layers of surgical gauze and used to prepared a culture medium contained rumen fluid; 100 ml, starch; 500 mg, cellulose and 500 mg urea; 64.4 mg and different level of sulphur (0, 1, 2, 3 mg/100 ml) and sulphur plus pyridoxine (1+0.01, 2+0.1, 3+1 mg/100ml). For each level of sulphur and sulphur plus pyridoxine considered four 125 ml bottles per inoculation time. The bottles with cultures incubated for five period (0, 2, 6, 12, and 24 h) at 39$^{\circ C}$. At the end of each incubation period the bottles contents centrifuged at 500 ×g for 10 min to remove feed particles and protozoa, then supernatant was centrifuged at 20000 ×g for 20 min to sediment bacteria. The supernatant was analyzed for N- NH_3 , SH_2 , pH and the sediment was dried for 24 h at 105$^{\circ C}$ and then weighted and was analyzed total nitrogen (bacterial crude protein). The experiment was performed as a randomized complete block design.

Results Adding different levels of S and S+B_6 to the medium cultures increased growth of bacteria. The highest bacterial dry matter and bacterial crude protein synthesis (BCPs) was with N:S ratio of 10:1 and the sulphur of 2 mg/100ml as well as the sulphur plus pyridoxine were 2 mg + 0.1 mg/100ml of inoculated cultures (Table 1.). The effects of sulphur and pyridoxine on N- NH_3 , SH_2 , pH in cultures was significant ($p<0.05$).

Table1 Effects of level of S and S+B_6 on *in vitro* BCPs, N- NH_3 , SH_2 , pH.

Item	Sulphur mg/100ml				Sulphur + Pyridoxine (mg/100ml)			SE	F
	0	1	2	3	1+0.01	2+0.1	3+1		
Bacterial DM (mg/100ml)	70.9^{a}	82.6^{b}	93.6^{c}	103^{d}	105^{d}	132^{e}	132^{e}	4.56	566.24**
BCPs (mg/100ml)	44.1^{a}	52.1^{b}	59^{c}	66.1^{d}	67^{d}	85.5^{e}	84.1^{e}	3.26	439.66**
N-NH_3 (mg/100ml)	29.9^{d}	26.3^{cd}	22.9^{bc}	20.7^{ab}	20.2^{ab}	16.9^{a}	22.2^{abc}	2.05	5.27**
SH_2 (mg/l)	1.5^{a}	2.3^{c}	3.7^{e}	3.87^{e}	2	2.7^{d}	2.7^{d}	0.311	14.59**
PH	6.44^{e}	6.37^{d}	6.28^{c}	6.18^{b}	6.15^{b}	6.06^{a}	6.12^{b}	0.027	36.18**

^{abcd} within a row, means lacking a common letter differ ($p<0.05$).
** indicates ($p<0.01$)

Conclusions These results confirm that sulphur and pyridoxine are important mineral and B vitamin for optimal growth of ruminal bacteria and maximum bacterial crude protein synthesis may occur with N:S ratio of 10:1.

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The effects of different levels of sulphur and pyridoxine on the microbial protein synthesis in Ghezel male lambs: 2. *in vivo*

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Introduction The sulphur and pyridoxine are necessary for synthesis of total sulphur amino acids by ruminal bacteria and required for optimizing growth of ruminal microorganisms. For example, Caneiro *et al* (2000) reported the concentration of total sulphur amino acids in rumen bacterial DM changed quadratically ($p<0.08$) as dietary S increased. NRC (1985) suggested an N:S requirement of 10:1 for ruminants. Low dietary S concentration can also depress microbial protein synthesis (Kandylis, 1984). The aim of this study was to investigate the effect of dietary sulphur and pyridoxine level on microbial protein synthesis in Ghezel male lambs on the *in vivo* condition.

Materials and methods Four rumen fistulated male Ghezel lambs with an initial body weight of (35±3 kg) were used to evaluate rumen microbial protein synthesized of these animals to sulphur and pyridoxine supplementation. Lambs fed for eight period with seven diets (14.25% CP & 2.35 Mcal/kg ME, DM basis) with different levels of sulphur (0.12, 0.16, 0.22, 0.38% DM) and sulphur plus pyridoxine (0.16+11.8, 0.22+51.8, 0.38+101.8 % and mg/kg DM). The source of S and B_6 supplement were Na_2SO_4 and pyridoxine HCl. The N:S ratio is 19, 14, 10 and 6 respectively. Lambs were housed in individual metabolic cages. The urine was collected for 7 days and purine derivatives (PD) were measured using the HPLC and estimation of microbial protein synthesis based on PD [microbial . N (gN/d) = 0.727 (PD mmol/d)]. The purine nitrogen index (PNI) calculated as the proportion of purine derivatives nitrogen (PDN) to the total urine nitrogen (UN). Data were analyzed to compare the effect of seven diets on PD, PNI and MNS by procedures of SPSS 11.

Results Increasing sulphur and pyridoxine levels of diets increased MNs, microbial protein synthesized g/kg digestible organic matter fermented in the rumen (DOMR), PNI and decreased blood urea nitrogen (BUN) (Table 1.). In each case the effect was significant ($p<0.05$). The highest values of MNs and PNI were in the diets containing 0.22% S and 0.22% S plus 51.8 mg/kg DM B_6 and was N:S ratio of 10:1. Regression analysis of data showed a positive relationship and strong correlation ($R^2=0.94$) between PNI and MNs (Figure 1).

Table 1 Effects of level of sulphur and pyridoxine on MNs, PNI and BUN.

Item	Diet								
	Sulphur %				Sulphur% + Pyridoxine (mg/kg)				
	0.12	0.16	0.22	0.38	0.16+11.8	0.22+51.8	0.38+101.8	SE	F
Microbial N synthesis (g/d)	4.53^{a}	5.83^{c}	6.78^{d}	5.21^{b}	7.05^{d}	9.52^{e}	5.13^{b}	1.68	79.4**
Efficiency of microbial N synthesis (g N/kg DOMR)	10.81^{a}	12.93^{bc}	14.64^{d}	13.07^{bcd}	14.26^{cd}	18.1^{e}	11.49^{ab}	2.4	37.73**
Purine nitrogen index	0.024^{a}	0.035^{ba}	0.053^{e}	0.032^{b}	0.047^{d}	0.071^{f}	0.038^{c}	0.015	111.85**
Blood urea nitrogen(mg/dl)	15.27^{e}	13.75^{d}	9.87^{b}	15.37^{e}	12.05^{c}	8.92^{a}	15.16^{e}	2.75	187.41**

^{abcdef} means within a row effect with different superscript differ significantly ($p<0.05$). ** indicates ($p<0.01$)

Conclusions Although, carbohyrate and nitrogen are the major nutrients supporting rumen microbial growth but this study indicates that in addition to those factors, sulphur and B_6 supplementation and N:S ratio of 10:1 is also necessary to improve the microbial nitrogen synthesis in ruminants.

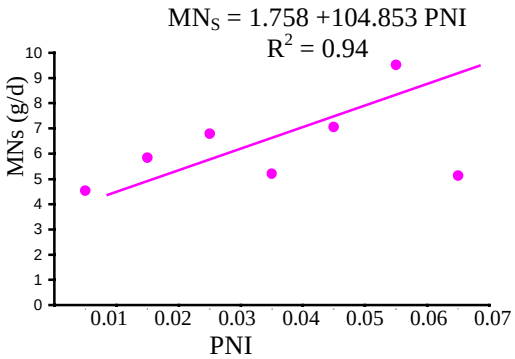

Figure 1 Regression relationship between PNI and MNs.

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In vitro rumen microbial yield from three different fibrous feeds using the radiophosphorous incorporation technique

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Introduction The determination or estimative of microbial protein supply is important to study the protein nutrition for ruminants. Microbial protein contribution to the total gut protein flow is very often considered as a constant based on feed intake. There are a great number of factors that can interfere on microbial synthesis and they are very difficult to be studied all together. The use of the *in vitro* radiophosphorous (^{32}P) incorporation technique allows studying isolated factors, because it is possible to control some of the factors involved. The aim of this work was to evaluate microbial nitrogen yield from poor, moderate and good quality hays and its influence on quality of rumen microbial population of sheep fed these hays.

Material and methods Three fibrous feeds were chosen according to their crude protein (CP) content: LUC – Lucerne (*Medicago sativa*) hay (CP = 191 $g.kg^{-1}$; NDF = 521 $g.kg^{-1}$; ADF = 191 $g.kg^{-1}$), SIG – signalgrass (*Brachiaria decumbens*) hay (CP = 29 $g.kg^{-1}$; NDF = 778 $g.kg^{-1}$; ADF = 470 $g.kg^{-1}$) and TIF – Tifton-85 (*Cynodon sp*) hay (CP = 75 $g.kg^{-1}$; NDF = 804 $g.kg^{-1}$; ADF = 461 $g.kg^{-1}$). Six Santa Ines sheep, fitted with rumen cannulas, were used as rumen liquor donors. Each two animals were exclusively fed each tested feed plus mineral mixture. The *in vitro* ^{32}P incorporation was conducted according to Van Nevel and Demeyer (1977) modified by Bueno (1998) and Gobbo (2001) in a 3x3 complete factorial design with three substrata (feeds) and three inocula (rumen liquor from two animals each). The assays were replicated three times using different animals as donors. Means were compared by Tukey test (probability level 5%) (SAS, 2000).

Results *In vitro* net yield of microbial protein after 8h of incubation with radiophosphorous is presented on Table 1. The analysis of variance showed effect for inoculum (P = 0.0089), but there was no effect for assays, substratum nor substratum*inoculum interaction (P > 0.05).

Table 1 *Microbial nitrogen yield (in mg MN.g^{-1} DM) estimated by in vitro radiophosphorous incorporation from Lucerne (LUC), signalgrass (SIG) or Tifton-85 (TIF) hays, using as inoculum rumen liquor from sheep fed the same hays*

inocula	*substrata*			*means*
	LUC	*SIG*	*TIF*	
LUC	2.36	2.83	3.05	2.75 [a]
SIG	1.77	1.26	1.28	1.44 [b]
TIF	1.33	1.59	1.49	1.47 [b]
means	1.82	1.89	1.94	

[a, b] means followed by different superscripts, within column, are significant different (Tukey test; P < 0.05)

The best inoculum was obtained from those animals fed LUC. As the incubation period was very short (8 h), the quality of inoculum was very important. To guarantee a fast and adequate microbial activity, the inoculum must supply a microbial population in ideal quantity and quality. The inoculum, even from donor animals submitted to a previous fastening, still had remains of substratum (soluble and particulate) that can supply initial energy to microbial growth during the lag time. This probably occurred for the inoculum from those animals fed LUC. Animals fed SIG or TIF, probably because these feeds presented lower nutrient contents, supplied energetically poorer rumen liquor and, therefore, of lower initial microbial activity.

Conclusion Although the *in vitro* ^{32}P incorporation technique cannot distinguish microbial growths from fermentation of tested feeds, it showed that poor quality feeds could not supply adequate microbial population for an efficient fermentation of fibrous feeds. Inoculum for *in vitro* feed evaluation must be obtained from animals fed at least enough nutrients to supply their requirements.

Acknowledgements Authors would like to thank FAPESP and CNPq for financial support.

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Estimative of rumen microbial growth based on urinary purine derivatives excretion by sheep fed three different quality hays

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Introduction The best amino acid profile for ruminants is indeed the rumen microbial protein profile. Thus feeds that promote a good microorganism growth are desirable to be a component of ruminant diets. The aim of this work was to estimate microbial protein supply to ruminant fed three protein level hays based on urinary excretion of purine derivatives.

Material and methods Three feeds were chosen according to their crude protein (CP) content: LUC – Lucerne (*Medicago sativa*) hay (CP=191 $g.kg^{-1}$; NDF=521 $g.kg^{-1}$; ADF=191 $g.kg^{-1}$), SIG – signalgrass (*Brachiaria decumbens*) hay (CP=29 $g.kg^{-1}$; NDF=778 $g.kg^{-1}$; ADF=470 $g.kg^{-1}$) and TIF – Tifton-85 (*Cynodon sp*) hay (CP=75 $g.kg^{-1}$; NDF=804 $g.kg^{-1}$; ADF=461 $g.kg^{-1}$). The animals used were Santa Inês wether (LW = 40 ± 5.7 kg) fed exclusively each corresponding hay and a commercial mineral mixture. The statistical design was a double 3×3 Latin Square, with 3 treatments (diets), 3 periods and 6 animals. After 22 days of adaptation to diets, urine samples (total collection) were taken for 5 days and analysed as individually poolled. Purine derivatives (PD) (allantoin, uric acid, xanthine and hipoxanthine) were determined by colorimetric methods (Chen and Gomes, 1992). The absorption of purines was estimated according to Chen et al. (1990) equation for sheep. Means were compared by standard error of difference between means (sed) and Student t test at probability level of 5% (SAS, 2000).

Results Urinary purine derivative profiles (Table 1) were quite different of normal excretion (hipoxanthine+xanthine: 5-10%; uric acid: 10-30%; and allantoin: 60-80% of total PD excretion as mentioned by Chen and Gomes (1992)). The small volume of excreted urine could be a clue for this low allantoin and high uric acid percentages. The microbial purine absorption (Table 2) on the gut showed that feed CP content has a strong impact on generation of microbial protein and on nitrogen supply to host animal. Animals fed LUC had greater microbial protein supply ($P < 0.05$). Although there were no differences ($P > 0.05$) between TIF and SIG, there is a visible trend regarding the low protein levels affected negatively the microbial protein flow.

Table 1 *Purine derivative (PD) profiles (% total) excreted via urine by sheep fed Lucerne (LUC), signalgrass (SIG) or Tifton-85 (TIF) hays*

PD	*Treatments*			*sed* †
	LUC	*SIG*	*TIF*	
hipoxanthine +xanthine	5.8[b]	6.3[b]	8.4[a]	0.78
uric acid	42.3	40.9	34.4	3.96
allantoin	51.9	52.9	57.2	3.89
total (mmol.d^{-1})	16.2	4.8	6.3	-

† standard error of difference between means
[a, b] means followed by different superscripts, within row, are significantly different ($P < 0.05$)

Table 2 *Microbial purine absorption and microbial N synthesis estimated from urinary excretion of purine derivatives for sheep fed Lucerne (LUC), signalgrass (SIG) or Tifton-85 (TIF) hays*

Parameters	*Treatments*			*sed* †
	LUC	*SIG*	*TIF*	
purine absorption				
mmol.d^{-1}	19.3[a]	4.9[b]	7.0[b]	1.67
µmol.kg$^{-0.75}$.d^{-1}	1172.6[a]	322.0[b]	438.3[b]	75.11
microbial synthesis				
g.d^{-1}	14.0 [a]	3.6[b]	5.1[b]	1.21
mg.kg$^{-0.75}$.d^{-1}	852.5 [a]	234.1[b]	318.7[b]	54.60
g.kg^{-1}.DOM$_R$	35.2 [a]	20.3[b]	24.8[b]	2.61

† standard error of difference between means
[a, b] means followed by different superscripts, within row, are significantly different ($P < 0.05$)

Conclusion The protein level of diets is directly related to microbial synthesis and microbial N supply for ruminants. Lucerne hay promoted the best results for microbial protein synthesis.

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Gas volume and microbial growth relationship using *in vitro* techniques related to feed quality

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Introduction The gas measured in an *in vitro* experiment is an indirect measurement of nutritionally important events. Feeds in the rumen are converted to short-chain fatty acids, to CO_2, to CH_4 and to microbial mass plus water. The pathways used for microorganisms for carbohydrate degradation will determine the amount of ATP available for microbial cell production and vary with the type of substrate, nature of inoculum and time of observation. The aim of this work was to study the relationship between gas volume and microbial growth regarding to the substrate quality.

Material and methods The *in vitro* gas production technique was conducted according to Theodorou *et al*. (1994), measuring the accumulated gas after 48h incubation. For this experiment five feeds (maize grain, soybean meal, maize silage, Lucerne hay and *Panicum* grass) were tested. Three adult wethers with rumen cannulas were used as rumen liquor donors. The inoculum consisted of 50 % liquid and 50 % solid phase (Cabral Filho, 2002). The results for the gas volume were fitted by France *et al.* (1993) model and *in vitro* degradability by Orskov & McDonald (1979) model. Acid-detergent fibre was estimated according to Van Soest & Wine (1967). The rumen microbial synthesis was estimated by the in vitro ^{32}P incorporation technique which is based on the constant ratio between nitrogen (N) and phosphorus (P) using the suggestions from Bueno, 2002. Gas accumulated after 48h were correlated to *in vitro* dry matter degradability (DEG) and N incorporated and the significance determined by the slope of the linear and quadratic regression analysis.

Results The measured gas was directly related to DEG but inversely to ADF ($P<0.01$). Maize grain presented the lowest ADF (44 g/kg^{-1}), the highest DM degradability (0.871g/kg^{-1}) and produced the highest gas volume (215 $ml.g^{-1}$ DM) (Figure 1). The N incorporated showed a quadratic relationship to degradability ($P<0.01$; $R^2=0.47$) for the tested feeds (Figure 1). This shows that high degradable substrates such as maize grain do not reflect higher microbial synthesis. This may be explained by the high microbial metabolism and the non-synchronism between N and energy available to the microorganisms. It is important to remember that the feeds used in this work contained different amounts of fibre and protein, which might explain the quadratic behaviour and the low N incorporated. Fibrous feeds (maize silage, Lucerne hay and *Panicum* grass) showed higher N incorporated than low fibre feeds except for soybean mean that had better N incorporated probably due to the high CP (crude protein) available (Table 1). The gas produced, although very correlated to degradation of DM, was inversely correlated to N incorporated ($-13.9Nincorp^2 + 97.5Nincorp + 47.1$; $R^2=0.96$; $P<0.01$). This suggested that microbial growth were lower than the microbial metabolism (degradation).

Table 1 Chemical composition ($g.kg^{-1}$ DM) of five tested substrates

Substrates	DM	CP	NDF	ADF	DEG	ADF
corn grain	938	93	178	44	871	44
soybean meal	882	459	158	106	844	106
corn silage	278	72	378	308	602	308
Lucerne hay	433	187	335	329	503	329
Panicum grass	nd*	43	484	480	368	480

*****non-determinated

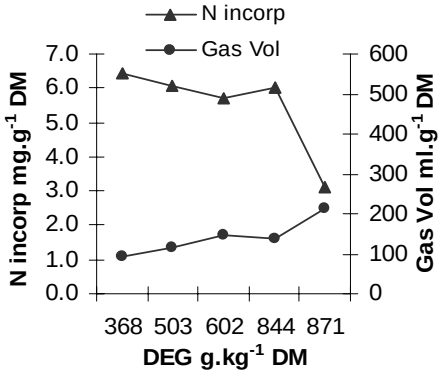

Figure 1 Linear regression between DEG, Nincorp and gas volume after 48h.

Conclusions Gas produced was higher when the microbial growth (N incorporated) did not follow the microbial metabolism (degradation) and thus the gas volume and N incorporated was negatively related. The most degradable feeds after 48h needed more CP and energy available in order to reduce gas production and support the microbial growth.

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In vitro dry matter degradation and metabolizable energy content of leaves of some trees in Turkey

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Introduction Tree leaves or shrub leaves are used in small ruminant diets in Turkey during the critical period of the year when quality and quantity pasture herbages is limited. The information about the leaves as a foodstuff for ruminant is limited. Therefore the aim of this study was to determine chemical composition, organic matter digestibility and metabolizable energy (ME) content of leaves of some threes and compare with wheat straw.

Materials and methods Tree leaves or shrub leaves are hand harvested in dry period (June- September), pooled and dried. 0.200 g of dry sample milled the through a 1 mm screen were incubated in triplicate with rumen fluid obtained two fistulated sheep fed a diet containing alfalfa hay (60%) and concentrate (40%) following procedures of Menke *et al.* (1979). Readings of gas production were recorded before incubation (0) and 3, 6, 12, 24, 48, 72 and 96 h. ME values were obtained using equations (ME (MJ/kg DM) = 2.20 + 0.136 Gp + 0.057 CP R^2 = 0.94). One-way analysis of variance (ANOVA) was carried out to compare the gas production and estimated parameters of three leaves.

Results As can be seen from Table 1 tree or shrub leaves are considerably rich in terms of crude protein when compared with wheat straw.

Table 1 Chemical composition (% of dry matter (DM) of tree leaves

	Wheat straw	Viburnum opulus L.	Carpinus betilus	Antragalus flevescens B.	Vitis vinifera L.	Quercus coccifera
Dry Matter	94.49	93.03	93.40	92.52	90.41	94.00
C. Fiber	56.62	14.31	43.84	55.74	13.47	38.2
C. Protein	1.51	12.96	10.54	11.97	12.57	3.62
Oil	2.13	1.99	2.09	1.49	2.49	4.40
Ash	8.63	7.58	6.83	4.43	10.83	6.91

As can be seen from Table 2 gas production at all incubation times and ME values of all leaves used in this experiment are significantly (P<0.001) higher than wheat straw.

Table 2 Gas production and estimated parameters of forages when incubated with rumen fluid *in vitro*

Incubation Time (h)	Wheat Straw	Viburnum opulus L.	Carpinus betilus	Antragalus flevescens B.	Vitis vinifera L.	Quercus. coccifera	SEM
3	13.50^{a}	24.17^{b}	23.17^{b}	22.50^{b}	22.33^{b}	17.83^{c}	0.616
6	19.17^{a}	33.50^{b}	34.17^{b}	34.00^{bc}	31.17^{cd}	28.00^{d}	0.634
12	27.17^{a}	39.33^{b}	41.17^{bc}	43.17^{c}	41.50^{bc}	35.83^{d}	0.787
24	34.33^{a}	53.33^{b}	48.67^{c}	53.17^{b}	47.67^{c}	47.17^{d}	0.589
48	40.33^{a}	58.17^{b}	55.17^{bc}	57.33^{b}	53.83^{cd}	50.83^{d}	0.619
72	43.17^{a}	62.83^{b}	61.83^{b}	61.17^{bc}	58.50^{c}	53.33^{d}	0.656
96	45.53^{a}	66.00^{b}	64.17^{bc}	63.50^{bc}	62.67^{c}	54.50^{d}	0.656
			Estimated parameters				
c	0.08^{a}	0.10^{ab}	0.10^{ab}	0.12^{b}	0.11^{ab}	0.09^{ab}	0.006
a	2.03^{a}	4.37^{b}	4.44^{b}	2.29^{a}	2.81^{ab}	2.41^{a}	0.417
b	40.52^{a}	57.33^{b}	55.98^{b}	57.38^{b}	55.11^{ab}	50.53^{c}	0.804
a+b	42.93^{a}	61.70^{b}	60.40^{b}	59.68^{b}	57.92^{ab}	52.91^{c}	0.859
ME	6.95^{a}	10.18^{b}	9.41^{c}	10.11^{b}	9.39^{c}	8.31^{d}	0.080

Means in the same column with different letters are different (P<0.001)

Conclusions The result suggest that tree or shrub leaves have a potential value to be a good quality foodstuff due to high protein content and ME energy when compared with wheat straw.

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Comparison of dry matter degradation and metabolizable energy content of tumbleweed silage with maize and alfalfa silage using *in vitro* gas production technique

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Introduction Forages, either fed as a silage or hay, represent a major component of ruminant diets. Tumbleweed (Gundelia Tournefortii L.) is a perennial spiny herb. In central Anatolian generally tumbleweed is collected and dried for winter fodder. There is no information about tumbleweed silage. The aim of this study was to compare tumbleweed silage with alfalfa and maize silage in terms of dry matter degradation and metabolizable energy (ME).

Materials and methods Tumbleweed, alfalfa and whole crop maize were ensiled in sealed drums with no additives. The resultant silages were incubated in triplicate with rumen fluid obtained from two fistulated sheep fed a diet containing alfalfa hay (60%) and concentrate (40%) following the procedures of Menke and Steingass (1988). Readings of gas production were recorded before incubation (0) and 3, 6, 12, 24, 48, 72 and 96. ME values of silages were obtained using equation (ME (MJ / Kg DM) = 2.20 + 0.136 Gp + 0.057 CP, R^2= 0.94) of Menke et al. (1979). Gp = 24 h gas production (ml), CP = Crude protein content (%). One-way analysis of variance (ANOVA) was carried out to compare the gas production and estimated parameters of forages.

Results Analysis of three silages sources (Table1) showed that crude protein ranged from 9.48 to 19.15, crude fibre from 25.87 to 33.54, oil from 2.42 to 3.92.

Table 1 Chemical composition (%) of Tumbleweed, Alfalfa and Maize silages

Silages	Dry Matter (DM) (% of Fresh Weight)	Crude Fibre (% of DM)	Crude Protein (% of DM)	Oil (% of DM)	Ash (% of DM)
Tumbleweed	27.69	33.55	13.35	3.52	11.06
Alfalfa	26.57	25.87	19.15	2.42	5.87
Maize	30.47	35.85	9.48	3.92	8.99

Data for gas production and estimated parameters are presented in Table 2. There were significant differences (P<0.001) between gas production after 12 h and estimated parameters between silages. The gas production of maize silage at all incubation time was higher than those of tumbleweed and alfalfa silage. Therefore maize silage had a higher ME value than those of the others although it has low crude protein content. The extensive degradation of crude protein in tumbleweed and alfalfa silage may be one of the reasons why they have a low gas production.

Table 2 Gas production and estimated parameters of forages when incubated with rumen fluid in vitro

Incubation Time (h)	Tumbleweed	Alfalfa	Maize	SEM	Sig.
3	18.6	17.3	18.6	0.745	NS
6	27.0	25.3	27.0	0.608	NS
12	34.0	32.3	34.0	0.608	NS
24	54.0^{b}	49.6^{a}	57.3^{b}	0.793	***
48	66.0^{a}	63.3^{a}	69.6^{b}	0.638	***
72	71.6^{b}	68.6^{a}	76.3^{c}	0.577	***
96	73.0^{a}	71.3^{a}	78.0^{b}	0.693	***
Estimated Parameters					
c	0.05	0.04	0.05	0.001	NS
a	4.17	4.06	4.10	0.276	NS
b	68.1^{a}	66.7^{a}	73.1^{b}	0.484	***
a+b	72.3^{a}	70.8^{a}	77.2^{b}	0.424	***
ME	10.3^{b}	9.4^{a}	11.0^{c}	0.107	***

Means in the same rows with differing superscripts are significantly different. SEM: Standard error mean, Sig. Significance Level. NS: Non significant, *** P<0.001

Conclusion This result suggest that tumbleweed silage is a forage with considerably high protein content and ME value and so it has the potential value to be a good quality forage for ruminant animals.

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Prediction of nutrient digestibility of grass silages from silage chemical and fermentation data

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Introduction Digestible nutrient concentrations in feeds are often used to estimate metabolisable energy (ME) concentration. The objective of the present study was to develop equations to calculate nutrient digestibility in silages from silage chemical and fermentation variables.

Material and methods A total of 136 grass silages were offered to sheep (4 sheep/silage) as the sole diet at maintenance feeding level to measure digestibility of dry matter (DM) (DMd), organic matter (OM) (OMd), crude protein (CP) (CPd) and neutral detergent fibre (NDF) (NDFd) and digestible OM in total DM (DOMD). The sheep were male Greyface and approximately two years old with live weights between 45 and 50 kg; and were housed in individual pens for three weeks before a 6-day total collection of faeces in metabolism crates. The silages had a large range in quality (DM 0.155 - 0.413 kg/kg, pH 3.5 - 5.5, ammonia-nitrogen/total- nitrogen (NH_3-N/N) 0.037 - 0.385 g/g) and a relatively even distribution over the range, and encompassed primary growth and first and second regrowth perennial ryegrass. The grass was either unwilted or wilted prior to ensiling and ensiled with or without application of silage additives. Gross energy (GE) concentration in silages was determined using undried silages in an adiabatic bomb calorimeter (Gallenkamp, Loughborough, UK). Silage DM concentration was determined on an alcohol-toluene basis, which was subsequently used as a basis of expressing all nutrient concentrations in silages. Linear, non-linear and multiple regression techniques were used to evaluate the relationships between nutrient digestibilities and variables of chemical composition and fermentation in the grass silages.

Results DMd, OMd and DOMD were positively related to CP, soluble CP, ether extract, lactic acid concentration and lactic-acid/total-VFAs ($P<0.05$ or less), while negatively related to ADF, NDF, lignin, individual VFA concentration, pH and NH_3-N/total-N ($P<0.05$ or less). CPd and NDFd had similar relationships with these parameters, although some relationships with fermentation data were not significant. CP, soluble CP, NDF and lignin concentrations in silages were most important predictors of nutrient digestibility with high R^2 values. The relationships between ADF or NDF concentration and digestibility data were linear, while the effect of CP concentration was curvilinear, especially on CP digestibility. Three sets of multiple prediction equations for DOMD and digestibility of DM, OM, CP and NDF were therefore developed using three sets of predictors (Table 1). The first set included CP, soluble-N/total-N (SN/N), DM, ash, NDF, lignin, lactic-acid/total-VFAs (Lac/VFA), NH_3-N/N; the second set excluded SN/N and lignin because they are not measured routinely in silage analysis; the third set further excluded the fermentation data. All relationships were significant ($p<0.001$) and each predictor had a significant effect on the relationship ($P<0.05$ or less). The R^2 values were reduced from 0.67-0.80 to 0.55-0.69 with the exclusion of some variables.

Table 1 Prediction equations for nutrient digestibility from silage chemical and fermentation data

	CP	SN/N	DM	Ash	NDF	Lignin	Lac/VFA	NH_3-N/N	Constant	R^2
DMd =	0.424	0.182	-0.230	-1.235	-0.431	-1.830	0.005		0.986	0.78
OMd =	0.437	0.146	-0.265	-0.989	-0.480	-1.741	0.005		1.040	0.78
DOMD =	0.406	0.135	-0.248	-1.600	-0.435	-1.628	0.004		1.009	0.78
CPd =	1.728	0.373	-0.299			-1.253		-0.183	0.363	0.80
NDFd =	1.091	0.222	-0.318	-1.156		-2.765	0.006		0.698	0.67
DMd =	0.625		-0.149	-1.498	-0.824		0.005		1.191	0.69
OMd =	0.613		-0.192	-1.225	-0.852		0.005		1.220	0.71
DOMD =	0.569		-0.180	-1.821	-0.783		0.005		1.177	0.70
CPd =	1.973		-0.210		-0.264			-0.173	0.605	0.71
DMd =	0.485			-1.720	-0.986				1.296	0.67
OMd =	0.500			-1.446	-0.997				1.301	0.68
DOMD =	0.461			-2.028	-0.919				1.254	0.67
CPd =	1.810			-0.662	-0.475				0.726	0.69
NDFd =	1.131			-1.880	-0.853				1.153	0.55

Conclusion Three sets of equations have been developed in the present study to predict nutrient digestibility in grass silages using silage chemical composition and fermentation data.

Acknowledgement The authors wish to thank their colleagues at the Agricultural Research Institute of Northern Ireland for access to the data used in the present study.

Validity of prediction of silage metabolisable energy concentration using digestible organic matter in total dry matter as a sole predictor

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Introduction AFRC (1993) recommends a factor of 16 to calculate metabolisable energy (ME) concentration in a grass silage from its digestible organic matter (DOM) in total dry matter (DM) (DOMD), irrespective of variations in the concentrations of other nutrients (crude protein (CP), carbohydrate and lipid) in DOM. The objective of the present study was to examine the effect of silage quality on the relationship between ME concentration and DOMD in grass silages.

Material and methods Two data sets of grass silages were used in the present study (published data and ARINI data). The published data (n = 21) were obtained from 12 studies published since 1973 in which grass silages were offered to sheep or cattle alone as a sole feed at or at near maintenance feeding level. The ARINI data (n = 174) were derived from studies undertaken at this Institute using sheep (4 sheep/silage) offered silages as the sole diet at maintenance feeding level. The ARINI silages encompassed primary growth and first and second regrowth perennial ryegrass and were either unwilted or wilted prior to ensiling and ensiled with or without application of silage additives. In both data sets, energy digestibility and urinary energy output were measured and methane energy output predicted. Silage DM concentration was determined on an alcohol-toluene basis for the ARINI data, while in the published data it was corrected on a toluene basis. Linear and multiple regression techniques and a mean square prediction error (MSPE) model were used to analyse the two datasets in the present study.

Results As silage quality varied greatly in the ARINI data, the energy concentration in DOM followed a normal distribution, ranging from 16.6 to 21.8 (mean 19.2, s.d. 0.99) MJ/kg DOM, with peak values being between 18.6 and 19.7 MJ/kg DOM. The large difference in energy concentration of DOM cannot be accounted for by differences in energy outputs in urine and methane when calculating ME concentration. This is supported by the published data; i.e., ME content per unit of DOMD increased significantly with increasing DOMD ($P < 0.05$) and concentrations of gross energy (GE) ($P < 0.01$), digestible energy (DE) ($P < 0.001$), ME ($P < 0.001$) and CP ($P < 0.05$). Similar results were also found in the ARINI data ($P<0.001$), although the relationship between ME/DOMD and DOMD was not significant. These results indicate that ME/DOMD is not a constant as AFRC (1993) recommended, but increases with increases in silage quality. Therefore the relationship of ME concentration with DOMD was much poorer than that with DE concentration (Table 1 Eqs. 1 vs 2, R^2 = 0.73 vs 0.98) when using the ARINI data. However, adding residual GE (ΔGE, actual GE – mean GE concentration (18.5 MJ/kg DM)) as a secondary predictor to the relationship between ME concentration and DOMD substantially improved the relationship (Eqs. 1 vs 3), with R^2 values increasing from 0.73 to 0.91. When using the published data and the MSPE technique to validate these equations (Table 2), the equation of AFRC (1993) and Eq (1) produced a large MSPE with large errors derived from bias (predicted – actual) and line (slope) and a small error derived from random variation in comparison with other three equations. The prediction errors derived from these two equations may be greater in poor or high quality silages. For example, in the published data the maximum over-prediction of ME concentration in poor quality silages was 1.2 MJ/kg DM or proportionately 0.13 of actual ME concentration, while in high quality silages the under-prediction was 1.3 MJ/kg DM or 0.10.

Table 1. Prediction equations developed using ARINI Data [#]

	Equations	R^2
(AFRC	ME = 16.00 DOMD)	
(1)	16.64 DOMD – 0.71	0.73
(2)	0.856 DE – 0.58	0.98
(3)	16.25 DOMD + 0.76 ΔGE – 0.40	0.91
(4)	14.94 DOMD + 7.32 CP – 0.56	0.75

Table 2 Validation using published data

	ME (MJ/kg DM)			Proportion of MSPE		
	Predicted	Actual	MSPE	Bias	Line	Random
AFRC	11.0	11.2	0.43	0.12	0.27	0.61
(1)	10.9		0.47	0.24	0.21	0.55
(2)	11.1		0.11	0.14	0.00	0.86
(3)	11.1		0.26	0.04	0.17	0.79
(4)	11.1		0.31	0.07	0.03	0.90

[#] Units are MJ/kg DM for ΔGE, DE and ME, and kg/kg DM for CP and DOMD

Conclusion Prediction of silage ME concentration using DOMD alone, as recommended in AFRC (1993), can result in significant errors in estimation. The error can be largely avoided by using DE or DOMD + ΔGE or CP as predictors.

Acknowledgement The authors wish to thank their colleagues at the Agricultural Research Institute of Northern Ireland for access to the data used in the present study

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Effect of treating whole-crop barley silage with urea on silage degradability

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Introduction In situ dry matter and protein degradation of urea supplemented whole-crop barley in the rumen of Mehraban rams were studied. DM degradability estimated from disappearance of DM from dacron bags. The degradable fraction CP is converted to ammonia, fatty acids and CO_2, with a portion of ammonia being used for microbial protein synthesis in the rumen. The undegradable fraction escapes digestion in the rumen and subsequently available for intestinal digestion and absorption.

Materials and methods Degradability coefficients of DM and CP were determined by using Dacron bags in three rumen fistulated rams. Bags were made of dacron having an average mesh size of 48μm. Approximately 5g (Oven dry) of the three diets (silage with 50 and 75 g/kgDM urea and silage without urea) placed in dacron bags which were tied shut with nylon string. Then the bags suspended in the rumen of the rams for 2, 4, 8, 16, 24, 48, 72 and 96 hr . At the end of each incubation time the bags were removed from the rumen and washed under running tap water untile the rinsing was colorless (approximately 1 min). Washed nylon bags were dried in oven at 65^0C for 48 hr. The content of each bag was subjected to Kjeldahl N analysis. The percent disappearance of dry matter (DM) and nitrogen (N) at each incubation time was calculated from the proportion remaining after incubation in the rumen. The disappearance rate was fitted to the following equation (Ørskov and McDonald 1974) $p = a + b (1 – e^{-ct})$. Degradability data were analysed using the Fig.P computer software.

Results Coefficients of DM and CP disappearence (g/kgDM) from dacron bags for each three diet are shown in table 1 and 2. Urea treatment resulted in an increase in degradability (a + b) of CP. Degradability of DM decreased for 50 g/kgDM urea-treated silage but increased slightly for 75 g/kgDM urea-treated silage.

Table 1 Mean degradability coefficients of DM

Coefficients	silage without urea	SEM	silage with 50 g/kgDM urea	SEM	silage with 75 g/kgDM urea	SEM
a	0.463	±0.008	0.436	±0.007	0.506	±0.006
b	0.346	±0.071	0.352	±0.044	0.332	±0.033
c	0.023	±0.007	0.026	±0.005	0.029	±0.005
a+b	0.809		0.788		0.838	

Table 2 Mean degradability coefficients of CP

Coefficients	silage without urea	SEM	silage with 50 g/kgDM urea	SEM	silage with 75 g/kgDM urea	SEM
a	0.789	±0.005	0.736	±0.006	0.757	±0.007
b	0.088	±0.013	0.146	±0.016	0.157	±0.023
c	0.060	±0.013	0.050	±0.008	0.043	±0.010
a+b	0.877		0.882		0.914	

Conclusion The results of the present study indicated that the addition of urea to whole crop barley silage at 0.75% fresh weight may be recommended in order to increase the feeding value of the silage.

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Effects of creep feed diets containing different supplemental proteins on performance of Arabi suckling lambs

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Introduction The growth rate of Arabi lamb during the suckling period (from birth to weaning at about day 100) is very slow particularly for lambs born in the autumn (Dabiri, 1999). Poor quality and limited quantity of feed for lactating ewes was shown to limit milk production, which was the main reason for slow lamb growth (Dabiri and Mosavi 2000). On the other hand, in conventional Iranian sheep production systems, a limited quantity of low quality supplemental feed (creep feed) is offered to the suckling lambs. I hypothesised that offering a higher quality supplemental creep feed ad-libitum would improve the growth rate of lambs. This would increase the number of weaned lambs for sale at earlier ages for the good market during Eid of Nooroz, the big national celebration in Iran. The growth of lambs may be affected by different sources of protein in the creep feed. Therefore, the aims of this experiment were to 1) compare the growth of lambs fed experimental supplements with the growth of lambs fed conventionally, and 2) compare the effect of diets containing different sources of supplemental protein on lamb growth.

Materials and methods Fifty suckling male lambs with similar conditions (4.18±0.006 kg birth weight) from a flock of autumn lambing of Arabi sheep of the Ramin Agricultural Research Unit of Shahid Chamran University were included in this experiment from day 14 until weaning at day 94. The lambs were divided into five groups of 10 lambs. Four groups of lambs were randomly allocated to four supplemental protein diets treatments with the fifth group fed the conventional diet in a completely randomized design. The supplemental protein diets were 1) soybean meal (SBM), 2)soybean meal and poultry by-product meal (SBM+BPM), 3) cottonseed meal (CSM), and 4) cottonseed meal and poultry by-product meal (CSM+BPM). In diets containing two sources of supplemental protein each source supplied 50% of the protein. Suckling lambs of the control group were the conventional feed. The diets were formulated according to NRC (1985) and were isonitrogenous (16% CP) and isocaleric (79% TDN) and had approximately similar concentrations of other nutrients.

Results Average daily gain (ADG) of lambs fed diets 1,2,3, 4 and control during the 94-d experiment were respectively 180 ± 6.7, 192.25 ± 2.85, 195 ± 3.27, 192.75 ± 3.33 and 148.12 ± 3.87 g/day. Thus, the growth rates of suckling lambs fed the experimental diets were significantly higher ($p<0.05$) than lambs fed the conventional diet. Dry matter intake (DMI) of the creep feed for lambs fed diets 1,2,3 and 4 were respectively 213.68, 269.12, 294.74 and 269.59 g/day (SE = 2.77). It was not possible to measure the DMI of the conventionally fed group. Average creep feed DMI of 4 experimental groups of lambs in periods of 14 to 28 days, 1 to 2 month and 2 to 3 month of ages were respectively 10± 0.54, 114.47±1.29 and 360.37±8.59 (g/day). Feed conversion (feed/gain) ratio of lambs fed creep diets 1 to 4 during whole period were 1.190 ±0.036, 1.4±0.017, 1.51±0.025 and 1.4± 0.023, respectively. This was not different between lambs fed diets 2 and 4 ($p>0.05$) when SBM or CSM replaced by BPM, but the difference was significant between lambs fed diets 1 and 3 ($p <0.05$). The average feed conversion ratio of lambs during the periods of 1 to 2 month and 2 to 3 month of age were 0.85±0.094 and 2.25 ± 0.097, respectively.

Conclusions The ADG of lambs fed supplemental protein creep diets were greater than the ADG of lambs fed conventional diets which resulted in about 5 kg heavier weaning weights. Within the experimental lamb groups, lambs fed diet 3 (CSM) had greater ADG, DMI of creep feed and best economic efficiency. DMI of supplemental creep feed was very low during the first month, intermediate in the second month and highest in the third month of age. Thus, it is recommended that a creep feed diet, like diet 3, should be offered to autumn-born Arabi suckling lambs.

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Fatty acid composition of liver lipids of kids fed sunflower oil supplemented diet

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Introduction In our previous study with kids (Marinova et al., 2001) it was shown that a sunflower oil supplemented diet changed deposition and distribution of body lipids. In this study, however, we are particularly interested on the effect of sunflower oil supplemented diet on the fatty acid composition of liver lipids of kids, due to the important role of liver in nutrient uptake and regulation of lipid metabolism.

Material and methods Two groups of five male kids (age 3 months) each were fed for 21 days iso-nitrogenous diets containing either no added fat (control), or experimental, sunflower oil added (2.5% of wet weight of concentrate). Liver samples were taken after slaughter, and lipids were extracted according to the method of Bligh and Dyer (1959). Methyl esters of triacylglycerols (TG) and phospholipids (PL) isolated by preparative TLC, were prepared by transmethilation with 2% (v/v) of H_2SO_4 in dry methanol for 15h at 43°C. The fatty acid composition was analyzed by gas chromatography. *t-criteria* of Student was used for statistical evaluation of results.

Table 1 Proportions of fatty acids in liver triacylglycerols and phospholipids of kids in response to feeding sunflower oil

Fatty acids	Triacylglycerols		Phospholipids	
	Groups			
	Control	Experimental	Control	Experimental
14:0	1.5±0.5	0.9±0.1	0.7±0.2	0.5±0.1
15:0	-	-	0.5±0.1	0.4±0.1
16:0	24.2±1.8	22.2±0.8	17.1±0.1	14.9±0.5**
16:1 7	3.5±1.2	3.2±0.2	1.1±0.1	1.1±0.1
16:1 9	-	-	0.9±0.2	0.6±0.1
17:0	-	-	1.4±0.1	1.3±0.1
17:1	-	-	0.9±0.2	0.4±0.1
18:0	15.3±0.4	18.0±0.6**	27.3±2.0	26.7±0.3
18:1 9	48.8±0.5	45.3±1.1*	28.5±0.8	26.9±1.6
18:1 7	0.7±0.1	1.6±0.6	-	-
18:2	6.0±0.9	8.8±0.8*	8.9±1.0	12.7±0.8*
18:3	-	-	0.5±0.1	0.8±0.1*
20:2	-	-	0.9±0.1	0.9±0.1
20:3	-	-	0.5±0.1	0.8±0.1
20:4	-	-	7.8±0.9	9.3±0.3
20:5	-	-	0.4±0.1	0.3±0.1
22:5	-	-	1.3±0.1	1.3±0.2
22:6	-	-	1.4±0.4	1.2±0.3
USFA	59.0	58.9	53.1	56.3

*P<0.05;**P<0.01; USFA - Unsaturated fatty acids.

Results The results presented in Table 1 show that the sunflower oil supplemented diet had a noticeable effect on the fatty acid profiles of liver TG and PL. In PL of the experimental animals, the content of C16:0 decreased significantly ($p<0.01$), whereas in TG only a tendency was observed. The majority of C18:0 and C18:1 in PL did not change, whereas in TG the relative part of C18:1 decreased ($p<0.05$), and that one of C18:0 increased ($p<0.01$). Most notably, animals fed sunflower oil diet exhibited increases in n-6 fatty acids, C18:2 ($p<0.05$) in both PL and TG, and C20:4 in PL. As a result of the observed changes in the relative parts of the individual fatty acids, the sum of the unsaturated fatty acids in TG remain the same, but that one in PL was increased. In sunflower oil treated animals the ratio of n-6/n-3 polyunsaturated fatty acids in PL was enhanced (6.1 *vs* 4.6), compared with the control group.

Conclusions The results of the present study demonstrate that in experimental animals receiving twice as much linoleic acid from the dietary sunflower oil, more linoleic acid escaped the full saturation in the rumen, and was absorbed by the gastrointestinal tract. The higher amount of so called desirable fatty acids (unsaturated plus C18:0), together with the reduction of cholesterol raising fatty acids (C14:0 and C16:0) reflect the positive effect of a diet rich in linoleic acid on the fatty acid composition of liver lipids.

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Effects of yeast culture supplementation on the performance of finishing Shal lambs

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Introduction During the recent years, considerable interest has been shown in the use of probiotics to improve health and productivity in livestock animals and the use of yeast cultures in ruminant diets has received notable attention (Newbold *et al* 1996). Results from various experiments indicate that these microorganisms are able to alter microbial digestion in the rumen and may have positive effects on the performance of animals (Wolht, *et al.* 1998). Although numerous studies investigated the use of yeast culture in cattle (either dairy or beef and also calves) little work has been done on the production response from the use of this feed additive in finishing lambs. Therefore, the aim of this experiment was to investigate the effects of Biosaf, a live yeast strain of *Saccharomyces cerevisiae* (Sc 47), on the performance of finishing Shal lambs.

Materials and methods Twenty-four three months old Shal lambs (mean live weight 33.2 ± 4.07 kg) were used for a period of twelve weeks in this experiment. The animals were randomly allocated by weight into two groups each consisted of three replicates of four lambs in a pen. They were given either a basal (Control) or yeast supplemented (Biosaf) diet after a 14 days adaptation period based on NRC requirements. Basal diet contained *ad libitum* access to Lucerne hay and barley straw (90: 10 ratio respectively), and concentrate (0.9, 1.2, and 1.4 kg for each 4 consecutive weeks respectively) on dry matter basis. Concentrate was fed in two equal portions at 8:00 am and 4:00 pm. The concentrate contained (g/kg) ground barley 540, wheat bran 230, cottonseed meal 130, dried beet pulp 80, and mineral/vitamin supplement 20. The only variable for Biosaf group was the addition of 5g supplemental Biosaf® ($5x\ 10^9$ CFU of *Saccharomyces cerevisiae* Sc 47, provided from Lesaffre), which were top-dressed on the concentrate of morning feeding. Live weight gains were measured biweekly and feed intakes was also determined for each group of replicates daily. Chemical composition of diet ingredients was also determined. Data were compared between the two groups for the whole experimental period by one-way analysis of variance using Minitab.

Table 1 Chemical composition of feed ingredients

	DM	g/kg dry matter		
Ingredients	g/kg	CP	NDF	ADF
Lucerne hay	910	127	435	345
Barley straw	935	33	755	475
Barley grain	910	920	235	135
Wheat bran	920	151	455	135
Cottonseed meal	935	315	405	305
Sugar beet pulp	940	67	395	195

Table 2 Effects of yeast culture supplementation on animal performance during 12 weeks of the experimental period

Parameters	Biosaf	Control	Sem	P value
Initial weight (kg)[a]	33.2	33.2	1.2	0.981
Final weight (kg) [a]	48.9	48.6	1.45	0.882
Daily gain (g) [a]	187	183	7.53	0.570
DM intake (g/d) [b]	1482	1544	30.3	0.220
FCR (kg feed/kg gain) [b]	7.90	8.43	0.09	0.016

Values are means of twelve animals (a) or three groups of replicates (b). Sem = Standard error of means

Results Chemical composition of diet ingredients are shown in Table 1. The mean value of dry matter intake was slightly lower in lambs received yeast supplementation diet compared to the control group (Table 2). However, the weight gain of the treatment group was higher at the end of the experimental period although this effect was not statistically significant. The mean daily live weight gain of treatment group was also slightly higher (187 v 183 g/d) than that of control group. The addition of yeast culture to the diet was also resulted in a significant difference ($p<0.05$) in feed conversion ratio (FCR) parameter in which the lower value observed from lambs receiving supplemental diet (Table 2).

Conclusions The results of this study demonstrated that the supplementation of *Saccharomyces cerevisiae*, Sc 47 to the diet resulted in an improvement on the feed conversion ratio (FCR) in finishing lambs with no improvement on dry matter intake. This could be attributed to the positive effects of live yeast culture on rumen microbial activities, which affect feed digestibility in the rumen and in turn may cause the efficiency of feed to be improved.

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Association of plasma leptin concentrations with fat depot accumulation in growing sheep

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Introduction Circulating concentrations of the adipocyte hormone, leptin, are associated with body fat levels in most species so far studied, including ruminants and non-ruminants. However, fat is deposited at different rates in the various adipose depots *eg.* subcutaneous, visceral and muscular due, in part, to different activities of the main lipogenic enzymes in each depot (Eguinoa et al., 2003). While the potential for leptin expression (via leptin m-RNA levels measured by PCR techniques) has been shown to differ between adipose tissues, and other tissues also, there is little data to show that circulating leptin concentrations are more, or less, strongly associated with the accumulation of fat in different adipose depots. The current study used growing lambs, fed to gain at different rates and to accumulate different quantities of fat, to investigate the relative strength of these relationships.

Materials and methods Twenty-four Texel x Cheviot lambs of similar age and weight (36.06 +/- 2.766kg) were allocated to 4 treatment groups of 3 males and 3 females each. One group (P) was selected for pre-experimental slaughter. The remaining groups were allocated to one of three levels of intake of a pelleted diet (0.475 grassmeal, 0.40 rolled barley, 0.10 soya meal and 0.025 mins + vit) providing 1.0 (A), 1.7 (B) and 2.4 (C) of maintenance ME requirement. Lambs were consuming their full dietary allocation by the end of week 3 and the amount of feed was adjusted once only, at the end of week 10, to take account of the increase in LW. Lambs were weighed and blood-sampled once weekly, prior to feeding, and were slaughtered after 17 weeks. Body condition score (BCS) was assessed on four occasions during the study. At slaughter, the rumen and gut were removed, separated, washed free of digesta and weighed. Omental fat (OF) and mesenteric fat (MF) were bluntly dissected from the rumen and intestines respectively, weighed and frozen. Fresh weights of all major components including rumen and foregut, intestines, hot and cold (48h chill) carcase and kidney (with renal fat) were all recorded. Renal fat (RF) was estimated by chemical analysis of a homogenate of the kidney and fat. Serum was assayed for leptin by a heterologous radio-immunoassay using recombinant bovine leptin (DSL, Oxford, UK) labelled in-house with ^{125}Iodine, a 1:160,000 dilution of guinea pig antiserum raised in-house against recombinant ovine leptin (Prof A Gertler, Hebrew University of Jerusalem) and goat anti-guinea pig Sac-Cel (IDS, Tyne & Wear, UK). Data were subjected to a Pearsons correlation analysis.

Results Plane of nutrition significantly affected (all $P<0.001$) all measures of performance: LW at slaughter (41.4, 49.5, 59.83 kg; s.e.m. 1.25), rate of gain (41.9, 120.1, 196.4 g/d; s.e.m. 8.16), overall BCS change (0.0, 0.20, 0.33 units; s.e.m. 0.05), cold carcass weight (17.1, 22.2, 26.3 kg; s.e.m. 0.576), washed rumen weight (1.71, 2.63, 3.50 kg; s.e.m. 0.095) and washed intestinal weight (0.71, 0.89, 1.27 g; s.e.m.0.037) for treatments A, B and C respectively. Diet, but not sex of lamb, also significantly affected ($P<0.001$) both leptin concentrations at slaughter (0.80, 2.44, 2.28 ng/ml; s.e.m. 0.237) and the increase in leptin over 17 weeks (0.06, 1.22, 1.25 ng/ml; s.e.m. 0.337). Total OF, MF and RF differed significantly with diet (A, B and C respectively) thus: OF, 253.2, 755.5 and 895.9 g (s.e.m. 65.0; $P<0.001$); MF, 54.9, 76.5 and 147.8 g (s.e.m. 18.40; $P<0.05$) and RF, 51.2, 237.3 and 259.1 g (s.e.m. 34.40; $P<0.01$). Fat in the carcase (the sum of subcutaneous, intra-muscular and inter-muscular fat) was also affected by diet with 2.41, 4.81 and 5.28 kg for diets A, B and C respectively (s.e.m. 0.373; $P<0.001$). Leptin concentrations at slaughter were significantly correlated with total fat content in all depots except MF and with the change in fat content over 17 weeks in the carcase and the OF depot only (RF change not determined) as shown in Table 1.

Table 1 Correlation of serum leptin concentrations at slaughter with absolute fat content and change in fat content in lambs.

	Total carcase fat	Change in carcase fat	Total OF	Change in OF	Total MF	Change in MF	Total RF
r	0.809	0.818	0.632	0.646	0.406	0.412	0.561
significance	P<0.001	P<0.001	P<0.01	P<0.01	NS	NS	P<0.05

Conclusions Increasing the plane of nutrition resulted in increasing but different levels of fat accumulation in the selected depots. In the current study, all lambs started the experiment with low levels of visceral and carcase fats so that, for each depot, correlations of leptin with absolute fat at slaughter and with change in fat were similar. Overall, leptin was most strongly correlated with carcase fat content whilst, among the visceral fats, the omental depot showed the best correlation with circulating leptin concentrations at slaughter. Omental fat is considered to be an important energy store in productive ruminants (especially dairy cows) and an enhanced relationship between leptin and omental fat could have additional significance for metabolic regulation in such animals.

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The effect of long-chain polyunsaturated fatty acid and vitamin E supplementation of pregnant ewes on neonatal lamb behaviour and lamb growth

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Introduction Long-chain polyunsaturated fatty acids (PUFAs) are essential components of cellular membranes and are associated with prostaglandin synthesis. Supplementing ewes with long-chain PUFAs during gestation has been demonstrated to increase gestation length and improve lamb vigour (Capper *et al*., 2002). Furthermore, increasing the dietary vitamin E supplied to pregnant ewes is reported to increase lamb growth rate (Gentry *et al*., 1992). However, fish oil supplementation during lactation may reduce milk component yield and lamb growth rate (Capper *et al*., 2002). The objective of this experiment was to investigate the effects of dietary long-chain PUFA and vitamin E supplementation of pregnant ewes on lamb performance.

Materials and methods Thirty Suffolk X Mule ewes were allocated to one of three treatments at 103 days of gestation and blocked according to age, liveweight and condition score in a randomised block design. Ewes were individually penned and housed from six weeks *pre-partum* to four weeks *post partum* and fed one of four diets. Diets fed during pregnancy contained either Megalac (M; saturated fat control) or fish oil (F) as the main fatty acid source; at 24 hours *post partum*, all ewes were changed to a lactation diet in which fish oil was replaced by Megalac . Each diet was formulated to provide a basal (B; 50mg/kg) or supra-nutritional (S; 500mg/kg) concentration of vitamin E. The concentrates were isoenergetic, isonitrogenous and provided 80g fatty acids/kg DM. Straw was offered *ad-libitum*. At lambing, lambs were focal sampled and the latencies of standing (lamb supporting itself on all four feet), searching for the udder (lamb has head upwards in udder region and is actively seeking the teat) and successful suckling (lamb has the teat in its mouth and appears to suck) were recorded. To avoid confounding behavioural observations, lamb birthweight data was recorded at three hours *post partum*, with subsequent weighings at 7, 14, 21 and 28 days of age. Ewes were milked at 21 days *post partum* and samples analysed by N.I.R.S. Data were analysed by ANOVA.

Results Gestation length was similar for all ewes, regardless of treatment diet (Table 1). Supplementing the diets of pregnant ewes with long-chain PUFAs (diets FB and FS) reduced the latencies of standing, searching for the udder and successfully suckling in lambs when compared to supplementation with a saturated fat source (diet MB), however, these differences did not reach statistical significance. Lamb birthweight and growth rate was unaffected by the provision of different dietary fat sources and vitamin E concentrations to ewes during pregnancy and lactation. Milk yields were similar between treatments, however a tendency ($P<0.1$) for milk fat yield to be reduced by fish oil supplementation during pregnancy was observed.

Table 1 Effects of supplementing pregnant ewes with long-chain polyunsaturated fatty acids and vitamin E on neonatal lamb vigour, growth and milk parameters

	Treatment Diet[a]				
	MB	FB	FS	s.e.d.	Significance
Gestation length (days)	147.5	147.5	147.7	0.74	NS
Latency of lamb standing (min)	15.6	12.9	11.8	2.46	NS
Latency of lamb searching for the udder (min)	17.5	13.8	14.9	3.21	NS
Latency of lamb suckling successfully (min)	44.3	40.0	40.7	6.11	NS
Lamb birthweight (kg)	4.74	4.57	4.70	0.268	NS
Lamb growth rate (kg/day)	0.30	0.30	0.31	0.013	NS
Milk yield (ml/hour)	106	101	106	11.8	NS
Milk fat yield (g/hour)	8.82	6.55	5.75	1.412	NS

[a] MB = Megalac throughout pregnancy and lactation, 50mg/kg vitamin E; FB = Fish oil during pregnancy, Megalac during lactation, 50mg/kg vitamin E; FS = Fish oil during pregnancy, Megalac during lactation, 500mg/kg vitamin E

Conclusions Supplementation of pregnant ewes with long-chain PUFA and vitamin E had no significant effects upon neonatal lamb vigour, milk composition or growth rate within the current study. However, differences in behavioural parameters may have been observed if the number of animals per treatment was increased. Although non-significant, the carry-over effects of fish oil supplementation during pregnancy upon milk composition warrant further investigation.

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Effect of CRYSTALYX® on the performance of breeding ewes in late pregnancy and post-lambing

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Introduction Nutrient requirements of the pregnant ewe increase with stage of pregnancy and with expected litter size. Foetal growth takes place principally during the final 6 weeks of gestation. As uterine volume increases with growing foetal size, rumen volume is decreased due to a lack of abdominal space. This can cause a reduction in dry matter intake in late pregnancy as lambing approaches. Even the introduction of supplementary concentrates in late pregnancy cannot always provide sufficient nutrients to the multi-foetal ewe, resulting in mobilisation of maternal body energy reserves to maintain foetal growth. The provision of a high energy feed supplement, available on a self-help basis, allows ewes the opportunity to "top up" their nutrient intakes. This study examined the effect of feeding Extra High Energy CRYSTALYX® (feed lick), containing sugars, oil, protein and minerals, on an *ad libitum* self-help basis on the performance of housed ewes fed silage and concentrates in late pregnancy and post lambing. This paper reports the final part of a full gestation and post-lambing study, the first stage of which was reported by Chaudhry et al. (2003).

Materials & methods Approximately 160 Mule ewes with an initial mean live-weight (LW) of 66kg were divided in mid October 2001 into Control (Cont) and Treatment (Treat) groups, balanced for age, weight and previous lambing records at the University Farm as reported by Chaudhry et al. (2003). They were flushed and maintained throughout early and mid pregnancy on adjacent fields of perennial ryegrass, with Treatment ewes having access to feed licks on a self-help basis. Expected litter size (from scanning data) confirmed high lamb numbers (over 2.2 per ewe) in both groups. About six weeks before the expected date of lambing, all ewes were weighed, condition scored and housed separately as the original Control and Treatment groups on a straw bedded floor in an open shed. Both groups had free access to drinking water while consuming grass silage (130g CP and 11.5 MJ ME /kg DM) to appetite, together with an increasing allocation of a home-mixed concentrate feed (160g CP and 13MJ ME /kg DM). The concentrate feed contained barley, sugar beet pulp, maize gluten feed, soybean meal, SoyaPass, molasses and a mineral supplement. Both groups received the same level of supplementary concentrates, but in addition, Treatment ewes had free access to feed licks up to lambing. Soon after lambing, the ewes together with their new born lambs were moved to individual pens. The lambs were numbered and weighed at birth. The ewes were also weighed and condition scored before they were moved out with their lambs as mixed groups onto various fields of ryegrass swards. No feed licks were offered to either group during grazing. The lambs were re-weighed after 80 ($\pm$3.1, SD) days post-lambing to estimate their total (TLWG) and daily LW gains (DLWG) since birth. The data were statistically analysed by using GLM in SAS to examine the effect of the feed licks confounded by the shed area on the performance of these ewes and their lambs. Significance was declared if $P<0.05$.

Results are presented in the following Table.
The feed lick did not show any significant effect on the performance of either ewes or their lambs ($P>0.05$). This may be because the average CRYSTALYX® intake was only 33g/ewe/day during the 6 week of housing in late pregnancy. Such modest intake of CRYSTALYX® suggests that the plane of nutrition and the supplementary feed rates of 400g /ewe/day were adequate to meet the nutrient requirements of these ewes. The lack of any metabolic problems supports this observation. Despite the same birth weights, the Treatment lambs tended to show improved ($P>0.05$) growth rates by 5% compared with their Control counterparts even though no feed licks were offered during the post lambing period.

	Cont	Treat	s.e.m
Ewe & Lamb data			
Ewe LW *(kg)*			
At housing	79.9	79.8	1.2
Post-lambing	72.1	72.4	1.0
Ewe condition Score *(0-5)*			
At housing	2.4	2.6	0.090
Post-lambing	1.9	1.9	0.056
Live lambs born per ewe	2.12	2.17	ND
Feed lick intake *(g/ewe/day)*	0	33	ND
Lamb Birth weight *(kg)*	4.8	4.7	0.10
Total LW gain *(kg /lamb)*	21.9	23	0.73
DLWG *(g/lamb)*	277	291	9.00

Conclusions Although the performance of Treatment ewes that had consumed CRYSTALYX® during pregnancy was not significantly different from the Control ewes, their lambs tended to grow faster than those from the Control ewes. This suggests that the supplementation with even the modest amounts of feed lick may have helped these ewes to maintain body energy reserves in late pregnancy and enhance subsequent lactation performance post lambing. CRYSTALYX® intakes in late pregnancy can be used as a guide to adequacy of nutrient supply.

Acknowledgments We thank Jim Wightman, W. Hewison, David Routledge and other farm staff for their help.

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Voluntary herbage intake and diet selection in organic Scottish-Blackface ewes varying in body condition score, suckling twin lambs and grazing perennial ryegrass/white clover swards

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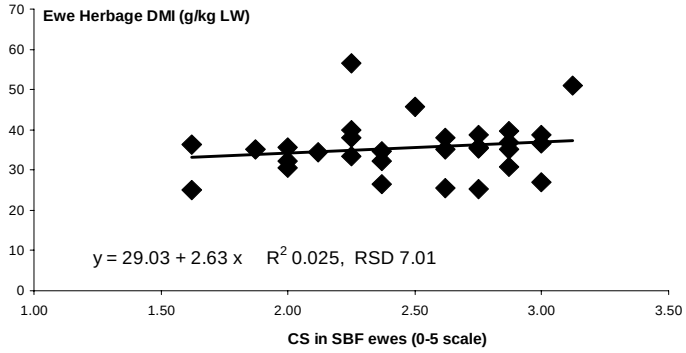
Introduction Previous work has shown that supplementing grazing ewes with soyabean meal increased total intake but did not influence dietary selection or herbage intake when sward heights (SH) were 4-6 cm (Hyslop *et al*, 2003). This study's main objective was to investigate body condition score (CS) as a possible factor influencing voluntary herbage intake and diet selection in 30 lactating Scottish-Blackface (SBF) ewes grazing different plots of mixed perennial ryegrass (PRG) and white clover (WC) swards.

Materials and methods A 2 x 3 factorial continuous randomised block design experiment was conducted to determine voluntary herbage dry matter intake (DMI) and diet selection in organic multiparous SBF ewes (mean LW 59.9 kg) suckling twin lambs. Experimental factors were CS and herbage plot area (PLOT) which varied in the proportion of PRG and WC available (managed at SH 4-5 cm, stocking rate 16 ewe/ha). Ewes were managed in two groups to achieve an average CS of either 2 or 3 at lambing. After lambing, ewes were grouped and randomly allocated to PLOT where all ewes received concentrate supplementation (Conc) at 0.9 kg/ewe/day. Voluntary herbage DMI and diet selection for 30 ewes was determined using the *n*-alkane approach (Dove and Mayes, 1991) on one occasion during 12th-16th May 2003 when ewes were on average in week 4 of lactation. Exogenous *n*-alkanes (C32 and C36) were administered to each ewe using a Captec® bolus and herbage DMI calculated assuming daily dose rates published by the manufacturer. Diet selection for each ewe was determined from *n*-alkane concentrations in herbage and faeces samples using a non-negative least squares procedure (Newman *et al*, 1995). Ewe LW and CS, herbage intake and diet selection data were subjected to analysis of variance using Genstat 5 and the relationship between total herbage DMI (PRG + WC) and ewe CS was investigated using regression analysis.



Results WC ground cover ranged from 6.7 - 14.6 % across the PLOTs. CS influenced the proportion of WC selected by SBF ewes with lower CS ewes selecting higher proportions of WC and lower proportions of PRG ($P<0.01$) but there were no other treatment effects on DMI figures (Table 1). Ewes grazing PLOT 1 also selected higher WC and lower PRG proportions ($P<0.05$) than the other two PLOTs. Overall, CS had only a negligible influence of total herbage (PRG + WC) DMI levels (Figure 1).

Figure 1 Total herbage DMI in relation to SBF ewe CS.

Table 1 Intakes and dietary proportions of PRG and WC in grazing organic Scottish-Blackface ewes at CS 2 or 3.

		CS			GRAZING PLOT				Sig of effects	
		2	3	sed	1	2	3	sed	CS	PLOT
LW @ recording period		59.3	60.5	1.98	60.2	61.0	58.4	2.42		
CS @ recording period		2.12	2.83	0.076	2.57	2.47	2.39	0.093	***	
DMI	Conc	0.76	0.76		0.76	0.76	0.76			
(kg/d)	PRG	1.37	1.50	0.151	1.54	1.52	1.24	0.185		
	WC	0.54	0.41	0.137	0.65	0.39	0.39	0.168		
	Total	2.67	2.67	0.244	2.95	2.68	2.38	0.299		
Total	g/kg LW	44.5	44.0	3.34	48.7	43.9	40.2	4.09		
Total	g/kg $LW^{0.75}$	124	123	9.73	136	123	112	11.92		
Dietary proportion	PRG	732	819	30.6	712^{a}	790^{b}	825^{b}	37.5	**	*
(g/kg)	WC	268	181	29.4	288^{a}	210^{b}	185^{b}	36.0	**	*

For grazing PLOT, values not sharing common superscripts differ significantly ($P<0.05$).

Conclusions At sward heights of 4-5 cm, ewes with lower CS selected higher proportions of WC from available herbage. CS had little influence on total herbage DMI by grazing organic Scottish-Blackface ewes suckling twin lambs.

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Effect of probiotic (Bifidobacterum and Streptococc) adding in the drinking water on performance and serum parameters of broiler chickens

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Introdution There is a world wide attempt to reduce antibiotic use in animal production because increased microbial resistance to antibiotic and residues in animal products can be harmfull to consumers.It is speculated that the benefit derived from probiotics is a result of the organisms growing and contributing some benefical function in the intestinal tract(Fuller ,1997).The objective of the present study was to determine the effect of the probiotic on performance and serum parameters of broiler chikens.

Material and methods A study was conducted to determine the effect of probiotic on the performance and serum parameter of broiler chickens In a completely randomized design with 4 treatment and 5 replicates on 240 day-old mail broiler chicken with a same weight average about (42±2 g) have been experimented , each of for level of probiotic added to drinking water (0 ,0.5 , 1 and 1.5 dose). were given to the chicken for 42 days.we have weight them for each week .At the age of 21 and 42 days one chicken each pen has been selected randomly for blooding and slaughtered . 4^{cc} of blood get from the jugular vein and was transfered to the laboratory for determined serum parameters (Jin,1998). Data were analyzed using the General Linear models procedures of SAS(SAS Insititute 1988) .

Results with the view of feed intake there is not significant defferent between the teratment are shown in Table1.but the average of body weight and feed conversion in the period of 0-21 days was influenced by the teratment ($p<0.05$) . the amount of cholesterol and serum HDL at 42 days of age was influenced by the teratment ($p<0.05$), but triglyceride there is nat significant defferent between the teratment are shown in Table2.

Table1 Mean feed in take (g) ,weigh gain(g) and feed conversion

variable	control	Control+0.5dose	Control+1dose	Control+1.5dose
0-3 Wk				
Feed intake	1007.26^{a}	972.71^{a}	984.63^{a}	982.48^{a}
Weight gain	553.96^{a}	567.64^{ab}	579.8^{ab}	598.82^{b}
Feed conversion	1.8^{a}	1.71^{b}	1.69^{b}	1.64^{b}
3-6 Wk				
Feed intake	3271.4^{a}	3243.4^{a}	3210^{a}	3168.6^{a}
Weight gain	1295.4^{a}	1295.67^{a}	1323.84^{a}	1328.5^{a}
Feed conversion	2.54^{a}	2.55^{a}	2.42^{a}	2.38^{a}
0-6Wk				
Feed intake	5235.02^{a}	5220^{a}	5229.8^{a}	5209.4^{a}
Weight gain	2417.36^{a}	2444.02^{a}	2446.06^{a}	2447.34^{a}
Feed conversion	2.16^{a}	2.13^{a}	2.13^{a}	2.12^{a}

Means wihtin Rows no common superscript differ significantly($p<0.05$).

Table 2 Mean serum Cholesterol,HDL and Triglyceride (mg/dl)

variable	Control	Control+0.5dose	Control+1dose	Control+1.5dose
3 Wk				
Chlesterol	130.02^{a}	119.7^{a}	116.84^{a}	115.84^{a}
HDL	80.16^{a}	96.86^{a}	88.86^{a}	80.3^{a}
Triglyceride	155.54^{a}	138.78^{a}	102.56^{a}	181.52^{a}
6 Wk				
Chlesterol	145.22^{a}	139.48^{a}	136.92^{a}	116.34^{b}
HDL	86.1^{a}	113.48^{b}	112.92^{b}	105.42^{b}
Triglyceride	109.82^{a}	142^{a}	164.64^{a}	155.56^{a}

Means wihtin Rows no common superscript differ significantly($p<0.05$).

Conclusions the results of the peresent study demonstrate that adding probiotic to a drinking water in above level affected the average of body weight and fed conversion at 21 days of age and the amount of cholesterol and HDL at 42 days of age.There fore feeding probiotic has potential to improve performance of broiler chickens.

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The effect of retinol acetate level in feed mixtures for broiler chickens on growth and physico-chemical traits of meat

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Introduction One of the most common reason of poultry deaths, their growth inhibition and decrease of body weight in first weeks of chicken life is the vitamin A deficit (Ziele, 1998). The aim of this work were studies, which can help to state the optimum vitamin A concentration for fast growing broilers and to show how vitamin A influences the chicken growth and physic-chemical traits of their meat.

Material and methods The study was carried out on 640 one-day-old broiler chicken Ross breeds randomly divided into four groups. All birds were fed with complete mixtures, which differed in the addition of vitamin A as retinol acetate (BASF, Kutno, Poland). The vitamin A level for in mixtures for control group (I) was 12 000 IU/kg of starter mixture and 10 000 IU/kg of the grower mixture. Group II was treated as a negative group with vitamin A level 50 % lower than recommended. In III and IV groups the vitamin A level was higher respectively 125 % and 150 % than in control group. During the 21 first days of life chickens got the starter mixture contained 210 g/kg^{-1} of total protein (CP) and 12.4 MJ metabolizable energy (EM) in 1 kg^{-1} of mixture, and then the grower mixture with 195 g/kg^{-1} CP and 12.6 MJ EM/kg^{-1}. All the mixtures contained the following supplements of vitamins respectively: period 1-3.0 thous. IU/kg^{-1} D_3, period 2 - 2.0 thous. IU/kg^{-1} D_3, period 1 and 2 - 33 IU/kg^{-1} vitamin E. At 49 day of age, 10 chickens from each group were slaughtered. In the meat samples of their breast muscles the chemical composition was evaluated (Budsławski i Drabent, 1972), water absorption by Grau and Hamm method (1953), the meat drip after 24 hours of storage in +4 ^{0}C, heat loss as a result of cooking and tenderness using the Instron 5542 apparatus (Instron, England) equipped in the Warner-Bratzel cutting knife. Moreover, the pH of *pectoral muscles* was evaluated in 15 minute ($pH_{15min.}$) and in 24 hours (pH_{24h}) after slaughter using the pH meter CyberScan 10 (Eutech, Singapore). The obtained results were worked by the analysis of variance and Tukey's test.

Results Significantly lower body weights of 21 days old chickens were observed in the group getting 50% of recommended vitamin A dose comparing to chickens getting 100 %, 125 % and 150 % of dose, respectively: 465±63.5bB, 551±61.7aA, 549±59.5aA and 549±55.6aA g. Also in II group higher chickens' mortality was observed 2.0 %, but in other groups respectively: 1.32 % -I, 1.32 % -II and 1.33 % in IV group. The higher additions of vitamin A for chickens during the rearing period had not any significant effect on physic-chemical meat traits except the water absorption – in II group getting the lowest vitamin A level the significant improvement of ability to water keeping in *pectoral muscles* (P<0.01) comparing to group I, III and IV. Moreover, the tendency to higher level of crude protein and higher meat tenderness of *pectoral muscles* in chickens group getting 50 % of recommended vitamin A dose was stated.

Table 1 The effect of the retinol actetate addition for chickens on physic-chemical traits of their meat (n=10)

	Groups				
Item	I	II	III	IV	SEM
Dry matter (%)	25.2	25.3	25.2	24.9	0.13
Ether extract (%)	1.05	0.98	0.87	0.86	0.08
Crude protein (%)	24.6 ab	25.0 a	24.3 ab	24.2 b	0.21
pH_{15min}	6.29	6.25	6.30	6.23	0.04
pH_{24h}	5.98	5.93	5.98	5.98	0.02
Water binding capacity (%)	16.7 C	10.0 A	15.4 B	22.4 D	0.25
Thermal losses (%)	12.8 a	13.7 ab	13.9 b	13.4 ab	0.26
Shear force (kg)	1.95 a	1.83 a	2.08 b	1.90 a	0.03
Drip loss (%)	0.46	0.57	0.60	0.61	0.05

a,b P<0.05; A,B - (P<0.01)

Conclusion Summing up we can say that the vitamin A addition in amount of 50 % of recommended dose caused the growth inhibition in first period of rearing. The increase of vitamin A dose to 125 % and 150% of norm in mixtures had an effect on the increase of the water absorption indicator and by this it decreased the ability to stop the water binding capacity in *pectoral muscles*.

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Effects of poultry fat, tallow, sunflower oil and their combination on performance and abdominal fat of two-broiler strain

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Introduction One of the major problems of poultry production is high cost of feeds. The supplementation of broiler diets with fats and oils is the most practical method for increasing the energy density, stimulating growth and utilisation of energy, improving the consistency and palatability of mash (Peebles et al. 1999). The type of fat inclusion in broiler diets has been shown to influence on carcass fat quality, because dietary fatty acid are incorporated with little change into body fat (Sklan and Ayal, 1989, Scaife et al 1994). Inclusion of fat in the diet may be influenced by the interaction between different added fats sources in the basal diets. This study was conducted to evaluate the effect of various sources of dietary supplemented fat on performance and abdominal fat of two-broiler strain.

Material and method Eight hundred and sixty four day old chicks from two strain (432 Arian and 432 Ross) were fed a common basal broiler diet from 1 to 21 days. On day 22 up to 49 day the chicks were randomly assigned to six treatments with seventy-two birds per treatment and fed the experimental diets, which contain 40 g/kg different fat sources or their combinations. The eight dietary treatments were achieved by using one of three different fat sources in the formulation of experimental diet. Fat sources were: tallow (T), sunflower oil (S), poultry fat (P), sunflower oil+ tallow (50:50, S+T), tallow+ poultry fat (50:50, T+P) and sunflower oil+ poultry fat (50:50, S+P). Diets were formulated to be isonitrogenous (190 g/kg CP) and isoenergetic (12.76 MJ ME /kg). Live weight gain, feed intake and feed conversion ratio (FCR) chicken were measured weekly. The abdominal fat deposition was determined at the end of study. The data were examined by analysis of variance for the main effects of fat sources and broiler starin.

Results The effect of dietary treatments on feed intake; weight gain, FCR and abdominal ft are presented in table 1. Dietary fat sources did not influences (P>0.05) on liveweight gain, feed intake and feed conversion ratio (FCR). However, significant difference was obtained in the abdominal fat deposition and the extent of the effect is different in each lipid class with higher rate in sunflower oil and lower rate in the tallow+ sunflower oil. The strain had a significant effect (P< 0.05) on feed intake, live weigh gain and abdominal fat but feed conversion ratio (FCR) was not affected by strain.

Table 1 Effect of different fat sources on broiler performance[a]

	Fat sources						Broiler strain	
	T	S	P	T+S	T+P	S+P	Ross	Arian
Feed Intake (g/day)	110.02 ±3.42	114.02 ±4.15	108.18 ±4.94	114.72 ±4.89	108.98 ±3.75	117.61 ±3.39	119.96 [b] ±1.21	107.61 [a] ±1.98
Weight gain (g/day)	58.21 ±3.46	57.86 ±5.73	56.05 ±4.36	59.75 ±2.75	60.21 ±2.50	59.40 ±5.66	63.47 [b] ±1.79	55.47 [a] ±1.53
FCR	1.89 ±0.10	1.97 ±0.18	1.93 ±0.10	1.92 ±0.11	1.81 ±0.05	1.98 ±0.18	1.89 ±0.04	1.94 ±0.08
Abdominal fat (g)	42.5[ab] ±3.11	47.1 [b] ±4.34	40.6 [ab] ±2.62	39.2 [a] ±3.20	39.3 [a] ±2.61	40.2 [ab] ±2.91	46.6[b] ±1.27	36.0 [a] ±3.42

[a] mean in the same row with different superscripts within a trial differ (P<0.05).

Conclusion Different responses to fat sources on abdominal fat were probably related to their fatty acid composition and also influences on the fatty acid composition of broiler chicken carcasses. However, using poultry fat in broiler diets compare to tallow had superior effect on the reduction of abdominal fat.

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Performance and carcass measures of broilers maintained on diets containing Biomin growth promoter

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Introduction There has been constant efforts to increase animal protein intake in Nigeria. The need to provide protein at a low cost to consumers has stimulated continued search for new additives, which will increase the efficiency and growth rate and therefore level of production of poultry birds. This has led to the present use of growth promoters (variously called growth permitters, growth enhancers, biostimulators). Growth promoters are antimicrobials, synthetic agents or mixtures of these. These substances directly or indirectly enhance digestion and hence anabolism. They remove pathological conditions, inhibit the action of organisms causing damages to the intestinal tissues (Robin and Batty, 1986) and therefore cause growth promotion. This study reports the use of a commercial growth promoter recently introduced into the poultry market in Nigeria, on the performance of broilers

Materials and methods Eighty (80) day old broiler chicks were allocated to two experimental diets in a completely randomized design. At the starter and finisher phases there were 40 birds per treatment shared into 4 replicates with 10 birds each. Diet 1 was a control diet with no Biomin while Diet 2 had Biomin (Biomin-imbo, containing Zinc-Bacitrin as active ingredient) added to it at the recommended rate of 100 g per 100 kg of diet. At the end of 28 days, the diets of the birds were changed to finisher diets for a further 28 days. Body weight gain, feed intake, feed conversion ratio and carcass measures were estimated and statistically analysed with the SAS general linear model (SAS Institute, 1990) and significance between means separated by Duncan's multiple range test (Duncan, 1955).

Results Feed consumption, body weight gain, feed conversion ratio and metabolizable energy intake were significantly improved ($P<0.05$) with addition of Biomin to the diet both at starter and finisher phases (Table 1). The packed cell volume, red and white blood cells and plasma globulin, showed increased trend though not significant with addition of Biomin to the diet. Plasma total protein, albumin, eviscerated weight, breast, drumstick and heart were significantly ($P<0.05$) increased by the Biomin-based diet (Table 2).

Table 1 Effect of Biomin on performance of broilers

	Diet 1 (Control)	Diet 2
Parameters*		
Average daily feed intake (g)	76.18±0.93**a**	95.77±0.68**b**
Average daily weight gain (g)	34.09±0.23**a**	44.82±0.87**b**
Feed conversion ratio	2.23±0.21**a**	2.14±0.25**b**
Metabolizable energy intake (Kcal)	228.54±0.86**a**	287.31±0.58**b**

Table 2 Effect Biomin on haematological values, carcass measures and organ weights

	Diet 1 (Control)	Diet 2
Parameters*		
Packed cell volume (%)	23.00±0.58	27.00±0.60
Red blood cells (x 10^6/µl)	3.92±0.05	4.19±0.06
White blood cells (x 10^3/µl)	9.93±0.30	10.83±0.44
Plasma total protein (g/dl)	4.97±0.22**a**	6.00±0.06**b**
Plasma albumin (g/dl)	1.77±0.03**a**	2.43±0.18**b**
Plasma globulin (g/dl)	3.20±0.21	3.70±0.06
Breast (g)	260.00**a**	310.00**b**
Eviscerated weight (g)	990.00**a**	1210.00**b**
Drumstick (g)	146.00**a**	193.00**b**
Heart (g)	10.83**a**	15.00**b**

Note: values with different letters on same row are significantly ($P<0.05$) different. *Mean values with standard error of mean (SEM)

Conclusion The results of the study have shown that addition of Biomin to the feed of broilers enhances their performance through better feed conversion and metabolizable energy intake.

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Supplementation of wheat bran and brewer's dried grain diets with Roxazyme G enzyme for broiler feeding

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Introduction Processed agro-idustrial by-products are gradually becoming important as supplemental energy sources for poultry feeding in Nigeria. Agro by-products such as wheat bran (WB) and brewer's dried grain (BDG), on treatment with polysaccharidase enzymes have their nutritional status improved (Oldale, 1996) hence they can be used as alternative energy sources for poultry. The objective of this study was to asses the performance of broilers maintained on WB- and BDG-based diets supplemented with Roxazyme G enzyme.

Materials and methods Five starter and finisher diets were formulated such that at each phase WB and BDG completely replaced maize in the diets. Either of the WB or BDG diets at both the starter and finisher phases was supplemented with Roxazyme G enzyme; a commercial enzyme cocktail with ability to compliment the digestive enzymes of birds. It has polysaccharidase properties and so can break down complex carbohydrates (Oldale, 1996). A diet containing 40 g kg^{-1} maize and no WB or BDG was used as control. All the diets were made up with other conventional feed ingredients such that they supplied the required nutrients of broiler starter and finisher birds. Seventy-five day-old chicks were allocated to the diets with each diet having three replicates of five birds each. The birds were fed the starter diets for 4 weeks after which the diets were switched to the finisher ones for a further 4 weeks. Weekly feed intake and body weights of the birds were taken and used to determine their feed conversion ratio. Apparent nutrient digestibility of birds was estimated in a 5-day collection period. Carcass characteristics of the birds were estimated. All data were analyzed statistically by the analysis of variance (ANOVA) technique of Steele and Torrie (1960) and paired significant means separated by the least significant difference (LSD) method.

Results Feed consumption of the birds at the starter and finisher phases was depressed when maize was replaced by either WB or BDG (Table 1). But addition of enzyme to the WB and BDG diets resulted in a significant increase ($P<0.05$) in their consumption and conversion over the maize and non supplemented diets. Birds on the enzyme-supplemented diets had significantly ($P< 0.05$) higher weight gain than those on the control and non supplemented diets at the starter phase. Supplementing the WB and BDG diets with Roxazyme G enzyme enhanced the consumption and utilization of such diets through improved nutrient digestibility by the birds as earlier reported by Iyayi and Tewe (1998).

Table 1 Performance of Starter and Finisher broilers on experimental diets

	40 g/Kg Maize	40 g/kg WB	40 g/Kg WB +Enzyme	40 g/Kg BDG	40 g/Kg BDG +Enzyme
Starter Phase					
Parameters*					
Feed consumption (g)	390±10.46a	392±9.44a	418±10.67b	399±11.36a	401±11.14c
Weight gain (g)	141±8.35a	140±9.45a	156±11.69b	150±10.36ab	156±6.22b
FCR	2.76±0.12a	2.80±0.04a	2.67±0.20b	2.65±0.05 b	2.56±0.04b
Finisher Phase					
Parameters*					
Feed consumption (g)	735±19.15a	926±18.14ab	969±17.19b	821±12.91c	925±15.24ab
Weight gain (g)	221±7.98a	245±8.66ab	275±5.99b	224±8.25a	232±9.25c
FCR	3.32±0.33a	3.96±0.36b	3.36±0.36a	3.67±0.36c	3.90±80.45b

Note: Values on the same row with different letters are significantly ($P<0.05$) different
*Mean values with standard error of mean (SEM)

Conclusion Enzyme supplementation caused significant feed consumption and growth of the birds at the starter phase when the full enzyme complement in the GIT is still not developed. Commercial enzyme holds a promise for improved utilization of low-grade agro-industrial by-products for broiler production in Nigeria**.**

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Effect of enzyme supplementation in wheat and triticale based diets on broiler performance

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Introduction Cereal grains provide the bulk of energy in practical diets for broiler production. In the world wide wheat appropriate the second place for itself 'after maize' among the other grains in poultry industry application. Triticale is a hybrid of wheat and rye and its nutritive value vary between it's parents. It is established that the main antinutritional factor of these grains is soluble arabinoxylane that can inhibits digestion and absorption of nutrients in digestive tract and decrease the performance of broiler chickens (Bedford and Schulze, 1998). Soluble indigestible polysaccharides may also affect the water consumption in broilers (Van der Klis *et al*., 1993). Nowadays above mentioned problems are solved by supplementation of specific feed enzymes to the diets. Therefore the objective of this trial was to study the effect of wheat and triticale based diets on broiler performance and water consumption with and without enzyme supplementation.

Materials and Methods 144 day-old Arian male broiler chickens were kept on cages and allocated to 4 experimental diets with a 2×2 factorial arrangement in a completely randomized design. There were 36 birds per treatment shared into 6 replicates with 6 birds each. Iso caloric and iso nitrogenous diets were formulated at starter and finisher phases by use 60% of wheat and triticale with (+) or without (-) enzyme application. Enzyme levels were 0.06% and 0.1% of diet at starter and finisher phases respectively according to some study advices. The birds were subjected to standard routine management. Feed intake (FI), weight gain (WG), and feed conversion rate (FCR) were recorded at the end of starter and finisher phases and water consumption also measured at 7 and 14 days of age. Data were analyzed by using the GLM procedure of SAS (SAS Institute,1985), and significant differences between means separated by Duncan's multiple range test.

Results performance parameters of chicken at the starter, finisher and whole period of experiment as well as water consumption at 7 and 14 days of age are illustrated in bellow table 1. Because the interaction effects were not significantly different, so just the data of main effects are presented. Neither cereal nor enzyme showed significantly effects on performance and water consumption at starter period, but the effect of cereal on FI, WG, and FCR was significant ($p<0.05$), Although enzyme application just affected on FCR at finisher period. Analysis of whole period data showed the similar pattern to finisher phase.

Table 1 Performance parameters and water consumption of broiler fed with experimental treatments

	Age (day)									Water consumption (g/bird/day)	
	1-21			22-42			1-42				
Main Effects											
Cereal	FI(g)	WG(g)	FCR	FI(g)	WG(g)	FCR	FI(g)	WG(g)	FCR	7	14
wheat	898	498	1.81	2482[a]	1059[a]	2.40[b]	3380[a]	1557[a]	2.17[b]	69.36	125.68
triticale	899	491	1.83	2300[b]	906[b]	2.54[a]	3199[b]	1397[b]	2.29[a]	65.90	122.19
s.e.m.	21.18	19.21	0.06	71.93	37.76	0.06	69.00	37.72	0.06	2.76	6.96
Enzyme											
-	901	489	1.85	2417	969	2.50[a]	3318	1457	2.29[a]	67.64	125.08
+	897	501	1.80	2365	997	2.38[b]	2361	1498	2.17[b]	67.62	122.79
s.e.m.	21.18	19.21	0.06	71.93	37.76	0.06	69.00	37.72	0.06	2.76	6.96

[a, b] means with different superscript on the column are significantly different ($p<0.05$)

Conclusions under the condition of this study, it was concluded that wheat based diet can improve broiler performance compare to triticale based diet. It also seems that enzyme addition may be by removing antinutritional factor can decrease the feed conversion rate in two grains based diets. However, application of triticale as an alternative to provide energy in poultry ration need to do more studies.

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Effect of dietary levels of tallow and NSP degrading enzyme supplements on nutrient efficiency of broiler chickens

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Introduction Fat digestibility in broilers depends not only on fat type but also on the particular cereal grain that is used. There are considerable evidences showing antinutritive effect of NSP in cereals have a pronounced negative effect on digestibility of fat in young birds. An increase in intestinal viscosity depresses fat digestibility more in animal fat-based diets. Reduction in viscosity due to enzyme addition in such diets should exert a more pronounced effect (Danicke, 1999a). Significant interaction effect between dietary fat type and carbohydrase addition was also reported (Danicke, 1999_b). The objective of the present study was to examine the effects of dietary levels of tallow and NSP degrading enzyme supplements on broiler chickens.

Materials and methods In a completely randomized design experiment with a 3*3 factorial arrangement (tallow levels; 0, 20, and 40 g/kg and NSP degrading enzyme levels; 500 and 1000 mg/kg containing 1200 U/g arabinoxylanase and 400 U/g beta-glucanase, GNC Bioferm Inc., Canada) with 4 replicates of 4 birds each, 144 day-old Hubbard Classic male broiler chickens were fed wheat- soybean meal based diets containing 620 g/kg wheat. To make the diets isoenergetic and isonitrogenous with different tallow levels, corn starch was used. For nutrient digestibility using Cr_2O_3 as indigestible marker, feces samples were collected from 18-21 days of age. At 21 day s of age, two birds from each replicate of treatments were killed for ileal digesta collection. Data were analyzed using the general linear procedure of SAS (1986).

Result Apparent metabolizable energy (AME), apparent lipid digestibility of feces (ALD_f), apparent protein digestibility (APD), and apparent lipid digestibility of ileal digesta (ALD_i) are shown in table. AME in all treatments affected by tallow and enzyme levels ($P<0.01$). Increasing the level of tallow in the diet significantly reduced ALD_f ($P<0.01$) and enzyme addition significantly improved it ($P<0.01$). This improvement was highest when the level of tallow in the diet was at its maximum level (80.238 *vs* 68.791). APD was not affected by treatments but improved when enzyme added to each level of tallow. ALD_i was significantly reduced by levels of tallow but increased by enzyme ($P<0.01$).

Table Effects of different tallow and enzyme levels on AME (MJ/kg) and nutrient digestibilities (%) in broiler chickens from 18-21 days of age

	Tallow(g/kg)				Enzyme(mg/kg)				
	0	20	40	P values	0	500	1000	P values	SEM
AME	12.898^{a}	12.365^{ab}	11.368^{b}	0.009	11.158^{b}	12.319^{a}	13.155^{a}	0.008	0.2188
APD	81.609	80.662	80.657	NS	79.786	80.959	82.182	NS	0.7063
ALD_f	82.151^{a}	73.748^{b}	68.791^{c}	0.0001	67.723^{a}	76.738^{b}	80.238^{c}	0.001	0.0902
ALD_i	84.420^{a}	74.321^{b}	70.522^{b}	0.001	69.121^{b}	78.450^{a}	81.756^{a}	0.012	0.740

P values for tallow and enzyme effects were significantly different ($p<0.01$). AME, apparent metabolizable energy; APD, apparent protein digestibility; ALD_f, apparent lipid digestibility of feces; ALD_i, apparent lipid digestibility of ileal digesta, NS; not significant. The values in each row with different superscripts are significantly different ($p<0.05$)

Conclusions Under the condition of this experiment, it was concluded that increasing the level of Tallow to diets containing 620 g/kg wheat decreases their AME, ALD_f and ALD_i. Addition of NSP degrading enzyme to diets containing wheat also increases their AME, ALD_f and ALD_i .

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Effect of microbial phytase on performance and apparent digestibility of amino acids in male broiler chickens

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Introduction Phytic acid is present in grains and seeds as a mixed salt, complexed with various cations, proteins and lipids (Cosgrove, 1966). The phytate-protein complexes may reduce the utilization of the amino acids. Additionally, phytate may form complexes with proteases, such as trypsin and pepsin (Singh and Kricorian, 1982) in gastrointestinal tract. These complexes may reduce the activity of digestive enzymes with a subsequent decrease in the digestibility of dietary proteins. It has been reported that microbial phytase improves the utilization of amino acids in broilers (Ravindran et al., 1999a). The objective of the present study was to evaluate the effect of microbial phytase on performance and apparent digestibility of amino acids in broiler chickens.

Materials and methods Three hundred day-old male chicks of a commercial strain (Hisex) were wing banded**,** weighted and randomly allocated to five treatment groups with five replicates of 12 chicks in each floor pen. The treatments involved supplementation of 0, 250, 500, 750 and 1000 FTU microbial phytase/ kg of a commercial diet (adequate in phosphorus and calcium) from 0 – 28 days of age. During days 21 to 24, excreta from 4 birds of each replicate was totally collected after transferring to battery cages. The feces stored at -20 C, freeze-dried and analyzed for amino acids using HPLC. Live body weight, feed intake and feed efficiency were recorded weekly. Analysis of variance and Duncan's new multiple range test were conducted using the General Linear Models procedure of SAS (SAS Institute, 1990) appropriate for a completely randomized design.

Results Microbial phytase had a significant effect ($P<0.05$) on apparent digestibility of amino acids. As shown in table 1, 500 FTU of phytase / kg of diet, significantly increased digestibility of studied amino acids. Higher levels of phytase caused poorer digestibility. Phytase had no significant effect ($P>0.05$) on live body weight, feed intake and feed efficiency. Body weight was numerically higher in 250 FTU and decreased insignificantly as level of phytase increased.

Table 1 Effect of phytase on fecal digestibility of amino acids in male broiler chickens

Treat	*LYS*	*LEU*	*ILE*	*PHE*	*VAL*	*ALA*	*ARG*	*THR*	*HIS*
0	87.8^{b}	85.7^{b}	84.0^{ab}	86.4^{b}	77.4^{b}	92.2^{a}	90.6^{c}	82.2^{b}	88.0^{c}
250	90.7^{a}	89.4^{a}	87.2^{a}	90.0^{a}	85.4^{a}	84.4^{ab}	93.7^{ab}	86.3^{ab}	91.0^{a}
500	91.3^{a}	89.3^{a}	87.0^{a}	91.0^{a}	85.5^{a}	83.9^{ab}	94.4^{a}	87.4^{a}	91.4^{a}
750	87.9^{b}	85.7^{b}	83.4^{b}	86.4^{b}	80.5^{ab}	79.2^{b}	90.8^{bc}	82.3^{b}	88.7^{bc}
1000	89.7^{ab}	87.4^{ab}	85.0^{ab}	88.6^{ab}	82.8^{ab}	82.3^{b}	93.2^{abc}	85.3^{ab}	90.3^{ab}
SE	0.75	0.94	1.04	0.92	1.94	2.88	0.93	1.24	0.64

^{abc} Means in the same column with a different superscript are significantly different ($P<0.05$)

Conclusion The results under the conditions of this study indicated that supplementation of 500 FTU phytase /kg of a commercial diet increased apparent digestibility of amino acids in male broiler chickens. Supplementation of Phytase had no significant effect ($P>0.05$) on feed intake and feed efficiency.

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The behaviour of Przewalski horses (*Equus przewalskii*) during formation of bachelor groups

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Introduction Captive Przewalski horses are generally kept as harem bands consisting of several females with their offspring and one stallion (Tilson *et al*., 1988). These husbandry procedures together with an approximately equal sex ratio at birth, led to an abundance of surplus males (Boyd and Houpt, 1994). In 1986 the European Breeding Programme recommended the establishment of bachelor groups to manage the surplus males in a cost-effective way (Kolter and Zimmermann, 2001). There have been reports of severe and sometimes fatal aggression between stallions during or immediately after their introduction to established bachelor groups (Kolter and Zimmermann, 2001). The main objectives of this study were to investigate the changes in behaviour during and immediately after introduction of Przewalski horses to bachelor groups, taking into account the effects of other factors such as age. The results are discussed in relation to enclosure type, animal husbandry and the social behaviour of equids.

Materials and methods The introductions of male Przewalski horses to bachelor groups were studied on three separate occasions (Table 1). Data were collected during the first 24 hours after a horse was introduced to a new group (the initial period), and then for a further two or three consecutive days (the post-introduction period). Procedures were in place to prevent injurious aggression during introductions. A behaviour ethogram was developed and data were collected using scan and continuous sampling techniques. The data were analysed in regard to enclosure type, age class, rank and group size using Kruskal-Wallis ANOVA and Spearman's rank correlation tests. Dominance hierarchies were drawn up for each bachelor group and the rank orders of the relationship matrices were calculated using an interactive matrix procedure (de Vries, 1995). The linearity of each matrix was analysed using Landau's linearity index. Sample Ratio Association Indices and Chi-square tests were used to assess proximity between horses in different groups.

Table 1 Bachelor groups where introductions took place. All of the new horses were introduced on the same day to the respective bachelor groups.

Group	Enclosure	Size (hectares)	Bachelors	Age (years)	New members	Age (years)
Saupark (Germany)	Zoo pasture	10	1S, 2S	8	5S	8
			3S, 4S	7	6S	2
Eelmoor (U.K.)	Nature Reserve	40	1E	7	3E, 4E	1
			2E	5		
Hortobagy (Hungary)	National Park	2700	1H, 2H	2	3H	6
					4H	2

S=Saupark group; E=Eelmoor group; H=Hortobagy group.
1S-6S, 1E-4E, 1H-4H=individual horses within groups.

Results The level of aggression during the initial period was significantly higher than aggression levels during the post-introduction period (Kruskal-Wallis ANOVA, H=8.38, df=1, p=0.0038). Stallions had significantly higher frequencies of aggression than colts both during the initial introduction period and post-introduction (Kruskal-Wallis ANOVA, H=6.02, df=1, p=0.0142; H=4.44, df=1, p=0.035 respectively). Dominance hierarchies formed during the first 24 hours of the formation of a bachelor group. None of the hierarchies were significantly linear. Mutual grooming and play-fighting were rare (less than two acts per hour) during the initial introduction period. Colts were involved in significantly more play-fighting bouts than stallions after the initial period (Kruskal-Wallis ANOVA, H=6.04, df=1, p=0.014). There was a significant difference in the proximity between horses in different groups both during the initial introduction period and post-introduction (X^2=1042.1, df=56, p<0.0001).

Conclusion The frequency of aggression was higher during the initial introduction period of males to a bachelor group than post-introduction. Age was a factor affecting the frequency of aggression in newly formed groups. Most of the aggression was between stallions and fights were not observed between colts. Extra caution should be taken when bachelors are kept in relatively small enclosures during introductions and when horses mature because aggression frequency increases with age. Preferably, colts should be introduced to each other first to form bachelor groups and one or two stallions, of different age, should be added.

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Age, gender and coat colour do not predict reactivity in Thoroughbred (*Equus caballus*) foals' first experience of the auction ring

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Introduction Temperament can defined as "an aspect of an individual's general make-up characterized by dispositions towards particular patterns of emotional reactions, mood shifts and levels of sensitivity resulting from stimulation" (Reber, 1995: 788). How an animal handles or reacts to a novel object or scenario, that is, the amount of reactivity it shows, is often regarded as an important factor in the assessment of their temperament, though the scenarios tested with horses tend to involve situations that the animal may never again encounter, for example, a maze or a falling, open umbrella (eg. Visser, et al, 2003). Slabbert and Odendaal (1999) developed a test, based on measuring behavioural responses of untrained pups to stimuli of the kind they would encounter as part of their work as adult police dogs, that was found to reliably identify which puppies would later go on to be successfully trained for the job. Many Thoroughbreds will go through the auction ring as foals and/or as yearlings. As the auction ring bears a striking resemblance to the parade ring at most racetracks, this particular scenario may be a potentially valuable one for the purpose of predicting future behaviour. Horses are often quick learners of associations (eg. Kiley-Worthington, 1997: 175) and so a positive or negative first experience in the auction ring could later affect how the animal behaves in the parade ring before a race. Should a horse show signs of distress at the racetrack, it often expends energy, or may gallop too quickly rather than canter steadily on the way to the start, using up energy that could have been used in the race. This analysis investigated whether factors such as age, gender or coat colour are associated with differences in behaviour in the auction ring that could be predictive of a Thoroughbred's future behaviour. Data were also analysed to see if there was any evidence that the sire of the animals might have influence.

Materials and methods A total of 1426 weaned Thoroughbred (*Equus caballus*) foals were observed, by a single viewer, in the sales ring in one of two different auction houses. All the animals (m=892; f=534) were born between January and June 2002 and all but 11 (4 in USA, 4 in France and 3 in Germany) were foaled in either Ireland or Britain. The auctions took place in Ireland and in England during November 2002. The observer recorded a set of specific behavioural responses. These were grouped into three different categories, labelled (i) 'movement', (ii) 'fear' and (iii) 'defensive'. 'Movement' behaviours included hestitation and/or acceleration towards or from the exit, attempts made to push through the exit and breaking into a trot. 'Fear' behaviours consisted of freezing, defecating, pulling or stepping backwards, sweating between the legs, and the number or whinnies or squeals emitted, while 'defensive' behaviour was made up of rearing, bucking and kicking. For each animal a reactivity score was calculated within each category by summing the number of instances of each of the target behaviours in that category, and the total number of instances across all categories was also calculated. Therefore, for example, a foal that broke into a trot six times, whinnied once, was sweating between its legs and bucked once would score 6 in 'movement', 2 in 'fear' and 1 in 'defensive', thereby producing a total score of 9. Pedigrees and dates of birth of the foals were obtained from the auction catalogues.

Results The range for the total reactivity score was 0-40 (m=4.39; SD=4.38; s.e.m.=.116) while the scores on each of the three categories had ranges as follows: (i) 'movement': 0-20 (m=1.70; SD=2.48; s.e.m.=.066), (ii) 'fear': 0-30 (m=2.67; SD=3.09; s.e.m.=.082), and (iii) 'defensive': 0-4 (m=.02; SD=.18; s.e.m.=.005). Only 168 foals, or 11.8% of the sample, obtained a reactivity score of zero, suggesting that this did not appear to be a stressful procedure for them. As the scores were not normally distributed the Kruskal-Wallis test was used to determine if there were any significant differences in the total reactivity scores, or the reactivity scores on each of the three categories above, when the data were analysed by age or gender or coat colour. None was found to be significant. Binomial tests performed using only the total reactivity scores, found that the sire of the animal may be a more important factor. A total of 204 individual stallions were represented by the 1426 foals, of which 92 stallions were represented by 6 or more foals. There were 102 paternal grandsires, of whom 27 were represented by 6 or more foals and had at least two stallion sons represented. A statistically significant proportion of the foals by 10 of the individual stallions scored below the mean reactivity score. In the case of paternal grandsires, there were 7 stallions with a greater than expected proportion of their descendants scoring below the mean and a single stallion whose proportion of descendants scoring above the mean was significant.

Conclusions Folk theories with regard to links between gender or coat colour and temperament in horses, such as "fillies and chestnuts are more 'excitable' than colts and bays", have not been borne out by this analysis. While foals differ considerably in the amount of reactivity they display in this novel situation, age, gender and coat colour are not associated with these differences. Evidence does suggest, however, that there may be some degree of transmission of traits, or behavioural tendencies, through some stallions. The research is continuing.

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Manipulation of water soluble carbohydrate accumulation in two perennial ryegrass cultivars through frequent cutting: implications for pasture management for equines

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Introduction Plant breeders are developing perennial ryegrass (PRG) varieties with elevated water soluble carbohydrate (WSC) contents as these have been shown to enhance ruminant production (Lee *et al.*, 1999). However, it would seem wise to limit the intake of WSC by horses, as ingestion of high levels of WSC by horses has been associated with the onset of metabolic disorders such as colic and laminitis (Hinkley, 1997). It is not known whether the genetic potential of PRG to accumulate high levels of WSC is expressed under all conditions, and if WSC levels can be controlled through management. In this study the effect of frequency of cutting regime on WSC accumulation and dry matter (DM) yield of a high WSC accumulating PRG variety, AberDart was compared with a control variety, Fennema.

Materials and methods Eight replicated field plots (10m x 1.5m) sown with the PRG varieties AberDart and Fennema were managed under either a 3-cut regime (4 plots) (15 May, 26 June, 24 July) or a 6-cut regime (4 plots) (1 and 21 May, 11 June, 2 July, 1 August, 3 September) in 2002. In March 2002, the plots were topped and fertilised; with ca. 70, 35 and 35 kg/ha of N, P and K respectively. At each cut, plots were mown at 1400h, and 1 kg sub-samples were immediately taken, placed on ice, and transported to the laboratory (100 m away) whereupon samples were oven dried at 60^{o}C, milled through a 1 mm steel mesh and analysed for DM and WSC. Data were subjected to analysis of variance.

Results The results are given in Table 1. When managed under a 3-cut regime, the overall DM yield, average WSC content and total WSC yield of AberDart was significantly greater than that of Fennema. However, when managed under a 6-cut regime, there was no significant difference in total DM yield, and although there was a tendency for AberDart to accumulate more WSC than Fennema these differences were only significant for cut 6. There was no significant difference between the varieties in terms of total WSC yield under the 6-cut regime.

Table 1 Dry matter yield (t/ha) (DMY), total DM yield (t/ha) (TDMY), WSC content (g/kg DM), average WSC content (Av WSC) and total WSC yield (kg/ha) (WSCY) of AberDart (A) and Fennema (F) maintained under two cutting regimes.

Parameter	3-cut regime						6-cut regime					
	DM Yield			WSC content			DM Yield			WSC content		
	A	F	s.e.	A	F	s.e.	A	F	s.e	A	F	s.e
Cut 1	5.54*	4.20	0.27	266	200	38.2	1.04*	0.66	0.22	208	179	15.4
Cut 2	3.35	3.31	0.31	179	165	20.6	1.22	1.11	0.24	153	136	10.8
Cut 3	2.59	2.32	0.42	158*	97	19.3	1.22*	1.46	0.09	109	108	4.1
Cut 4	-	-	-	-	-	-	1.30*	1.22	0.04	147	148	22.2
Cut 5	-	-	-	-	-	-	1.63*	1.93	0.14	254	227	40.4
Cut 6	-	-	-	-	-	-	2.15	2.13	0.25	219*	149	17.4
TDMY	11.4*	9.83	0.35	-	-	-	8.56	8.51	0.19	-	-	-
Av WSC	-	-	-	201*	154	25.3	-	-	-	183	158	21.1
WSCY	-	-	-	2473*	1611	207	-	-	-	1621	1345	341

* Values in rows for Fennema and AberDart within a cutting regime for a given parameter are significantly different (P<0.05)

Conclusions AberDart did not accumulate significantly higher levels of WSC than the control variety under all conditions. Thus, more frequent cutting resulted in a reduced differential in WSC content between AberDart and Fennema compared with the 3-cut conservation regime (average differential being 16 and 34% respectively). Frequent cutting may result in the WSC fraction being constantly used for re-growth rather than being stored, and thus frequent topping, cutting or possibly tight grazing of pastures containing the so-called 'high sugar grasses' may be a strategy that could be employed by horse owners to help reduce pasture WSC levels.

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Effect of a novel midge repellent on midge density in the vicinity and behaviour of sweet itch-susceptible horses

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Introduction Sweet itch is a major problem for horse owners in parts of the UK where biting midges (*Culicoides* spp.) feeding on horses may cause considerable skin irritation, known as sweet itch, and behaviour modification. Some horses are more susceptible than others, and various compounds have been used as midge repellents. However often these products require frequent application and can have limited effectiveness. The objective of this experiment was to determine the influence of a novel midge repellent on the behaviour of horses and, as an indicator of repellent abilities, the number of midges landing on the skin of a human volunteer.

Materials and methods The experiment was conducted in N. Ireland, at a location know to be densely populated with midges. The compound tested was presented as a liquid spray, and was based on natural organic oils and herbs (Agrilab Ltd., York). The 1st part of the experiment was carried out in late summer evenings, using a number of human volunteers known to be susceptible to attack by midges. The volunteer dressed so that most of their skin was concealed, apart from one arm. The midge repellent was sprayed onto the arm, then exposed to the air for 10 minutes, followed by the untreated arm for 10 minutes. During this time, midges which landed on the arm where collected by a suction-powered pooter into a sealed container, then counted at the end of the test. The 2nd part of the experiment was undertaken between July and September, and used a total of 6 horses, known to be susceptible to sweet itch and had two treatments, control (Untreated: washing but no application) and treated. Horses were subjected to a programme of treatment with midge repellent for 6 days, followed by no treatment for 3 days. Each horse was washed with a perfume-free shampoo, then allowed to dry before spraying ~20 ml/100 kg bodyweight of repellent. The untreated group had only a wash and rinse. The 3-day routine was repeated in a cycle, so that there were 4 four horses at any one time being treated with midge repellent and 2 untreated. The behaviour of each horse was recorded during the two days following application (or control washing), for a period of 10 minutes each morning and evening. During each observation period, the incidence of modified behaviours of tail shaking, head shaking, feet stamping, tail rubbing and posture change were recorded, using 3 levels: no effect (behaviour not exhibited), mild (horse performed behaviour sporadically) and severe (horse repeatedly performed behaviour). Averaging the behaviour data across two days, and across two observation periods resulted in it broadly following a normal distribution pattern. Data were tested for normality, then analysed by analysis of variance, using mean incidence of each level of each behaviour category during a 3-day period.

Results The average number of midges collected during the human volunteer test was significantly higher from the untreated arm compared to the treated arm (18.7 vs. 11.4 midges; $P<0.001$). Treated horses showed a higher proportion of observations where there was no effect on tail movement, head movement, rubbing, stamping or posture (Table 1). These animals also had a lower incidence of severe behaviour alterations in tail movement, stamping and rubbing.

Table 1 Effect of midge repellent on mean proportion of observations exhibiting modified behaviour of horses

Behaviour category	Level	Treated		Untreated		Significance
		Mean	se	Mean	se	
Tail Movement	No Effect	0.45	0.029	0.18	0.038	***
	Mild	0.53	0.032	0.59	0.041	ns
	Severe	0.02	0.021	0.23	0.027	***
Head Movement	No Effect	0.47	0.037	0.30	0.047	***
	Mild	0.50	0.040	0.65	0.051	*
	Severe	0.03	0.013	0.05	0.017	ns
Rubbing	No Effect	0.67	0.035	0.39	0.046	***
	Mild	0.31	0.036	0.57	0.046	***
	Severe	0.02	0.012	0.04	0.016	*
Stamping	No Effect	0.39	0.031	0.33	0.040	*
	Mild	0.57	0.032	0.58	0.041	ns
	Severe	0.04	0.020	0.09	0.025	*
Posture change	No Effect	0.97	0.020	0.75	0.026	***
	Mild	0.03	0.020	0.23	0.025	***
	Severe	0.001	0.0051	0.02	0.0065	ns

Conclusions The results show that a herbal-based midge repellent had a significant effect on the number of midges landing on the skin of human volunteers. During times when horses remained untreated, they showed significantly higher incidence of aversive reactions to being bitten by midges. A reduction in behaviour modification, and suggestion that the number of midges landing on the animals was reduced, indicates that the welfare of horses during periods of high midge density was improved by the application of this product.

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Use of morphology traits to assess growth rates in Ardennes male foals

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Introduction Growth of the Ardennes draught horse is not well known as compared to other draught breed horses. Biometry is the science which allows a mathematical approach of measured parameters. The technic provides tools for assessments of growth, aids to diagnosis of skeletal pathologies and assessments of sports aptitudes. According to Martin-Rosset (1990), live weight correlates to the thoracic perimeter. The aim of this study is to use other morphology traits to assess growth rates in Ardennes males foals.

Materials and methods A group of 18 foals registered on the Belgian studbook of the Ardennes draught breed were maintained in standardized conditions. They were 8 months old at the beginning of the trial. They were offered a diet made of a concentrate feed at a rate of 1 kg/ 100 kg body weight and hay. They had also access to a pasture used mainly as paddock. Morphology traits - thoracic perimeter (TP), stature measured vertically from the withers (St), cannon circumference (CC) and body length (BL) – were recorded on all foals once every 7 weeks during an one year period. The live weight was also recorded. These sets of data were called measurement runs. Linear and non linear models were adjusted between live weights and morphology traits using the REG and NLIN procedures of SAS.

Results The mean age of the foals was 249 d at the beginning of the records and 557 d at the end. There were a total of 7 measurements runs from which 108 full data sets were used for statistical treatments, some data sets being uncomplete. Table 1 summarizes 5 regression equations which were compared on r^2 basis. The best fit model (r^2 = 0.961) included age (A), St and TP. When TP was used alone, as suggested by Martin-Rosset (1990), the determination coefficient fell to 0.918. Live weights were calculated for the heaviest, the medium and the lightest foals with records obtained at 9,5, 15 and 18 months of age. The calculated live weights are compared in table 2 with the recorded live weights. Equation 4 provided the closest estimation for the heaviest foal while it was with equations 3 and 1 that live weight was best predicted for the lightest and the medium sized foals respectively.

Table 1 : Equations to predict live weight from morphology traits and age; the bold figures being the calculated values which are the closest to the observed values

N°	Equations	r^2
1	LW = 0.108A + 5.8132 St + 3.8617 TP- 1038.6	0.961
2	LW = 4.6287 TP + 5.8611 St - 1129.1	0.954
3	LW = (TP^2 . BL) / 8733.2	0.952
4	LW = 7.8086 TP – 836.9	0.918
5	LW = 53.53 CC – 757.6	0.751

Table 2 : Measured and estimated live weights of the heaviest (M1), the lightest (M2) and the medium (M3) foals at 3 ages. The bold figure on a line indicates the predicted value which is the closest to the observed value

Foal	Live weight (kg) observed	Live weight (kg) predicted by equations				
		Equation 1	Equation 2	Equation 3	Equation 4	Equation 5
M1 9,5 m	424	437.7	451.0	449.6	459.**3**	420.1
M1 15 m	606	585.6	595.9	613.3	599.9	575.3
M1 18 m	652	637.0	638.3	667.6	646.7	607.4
M2 9,5 m	267	272.0	267.1	282.6	287.5	313.0
M2 15 m	385	404.4	393.5	385.9	396.9	446.8
M2 18 m	423	447.8	430.0	421.9	443.7	473.6
M3 9,5 m	426	413.3	422.5	434.1	435.9	393.3
M3 15 m	530	523.7	522.8	510.2	506.2	430.8
M3 18 m	545	543.7	532.6	518.8	517.9	436.1

Conclusions The results of the present study indicate that it is possible to assess live weight of Ardennes draught male foals when no balance is available –often the case with breeders- from morphology traits. This could be of interest to adjust feed intakes in order to avoid growth disturbances.

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The effect of age, time of onset and length of heat on the content of macro-elements in Arabian mares' milk

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Introduction Mineral elements are very important for young horses especially during the development period, not only because of their importance for bone structure, but also because they are significant components of many enzymes catalysing basic biochemical reactions in the organism (Anderson 1991). Most macro-elements are found both in bone and body fluids (Grace 1999). Lonnerdal (2000) suggested that there are some mechanisms in mammary glands that regulate the level of minerals in milk. The aim of this study was to evaluate of the influence of mares' age, onset of heat and heat length on macro-elements content in their milk.

Material and methods Research was carried out on 30 Arabian mares. Milk samples were obtained by hand milking at 2, 4, 6, 8, 10, 12, 14, 16, 18 20, 22, 24, 26, 28 and 30 days after parturition and they were stored at -22ºC until analysis. All milk samples were lyophilised in a Labor-Mim 950 device and then mineralised in a mixture of nitric and perchlorate acids (ratio 1:1.5). Ash samples were dissoluted and analysed in a Philips PU 9100 device. Phosphorus contents were evaluated according to the method of Gericke and Kurmies (Skumowski, 1975). Mares were divided into groups according to age (I – to 8 years, II - from 9 to 12 years, III - more than 13 years), the time of onset of heat (I – heat occurred 4 –7 day after parturition, II – 8-10 days, III – later than 11 days) and the length of heat (I – heat shorter than 3 days, II – heat 4-7 days long, III heat longer than 8 days). Data were analysed statistically using one way analyses of variance and Duncan's test.

Results It was found that mares of age 9-12 years (group II) produced milk with the lowest content of most of the macro-elements investigated. The differences for P, Mg, Na and K were highly significant. Milk from younger mares contained the highest level of Ca, P and K. The mares with earlier onset of heat gave milk with the lowest level of Mg ($P<0.01$) and Ca but with the highest content of P and K ($P<0.05$). Younger mares produced milk with the lowest Mg content and older mares with the highest level of Mg. Mares characterised by shorter heat produced milk with higher levels of Ca ($P<0.01$), K ($P<0.05$) and Na.

Table 1 The effect of Arabian mares' age, term of heat beginning and heat length on macro-elements content (mg/kg) in their milk

Factor		Ca content		P content		Mg content		Na content		K content	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Age	I	916.7	244.7	787.1^{Aa}	254.6	93.4^{b}	33.9	133.6^{C}	25.0	668.7^{Ec}	155.3
	II	907.8	189.6	694.8^{A}	201.7	91.2^{B}	33.9	121.8^{CD}	19.4	588.3^{E}	177.1
	III	915.3	193.9	717.3^{a}	284.9	102.6^{Bb}	36.1	138.4^{D}	21.2	622.4^{c}	159.7
Time	I	909.1	243.4	774.2	278.3	86.1^{FG}	43.2	132.6^{Hd}	21.4	661.4^{Je}	177.8
of heat	II	923.7	178.1	714.2	261.6	101.9^{F}	34.0	123.3^{HI}	23.5	599.2^{J}	170.5
	III	915.3	172.3	717.3	212.5	102.6^{G}	23.5	138.4^{Id}	23.4	622.4^{e}	114.4
Length	I	991.6^{KL}	229.3	743.6	243.9	94.0	37.8	133.2	22.5	649.4^{f}	162.8
Of heat	II	897.8^{K}	202.1	748.2	243.8	101.8^{M}	35.8	131.7	24.2	636.9	184.6
	III	857.4^{L}	164.4	722.8	274.3	89.7^{M}	28.1	131.3	21.9	607.5^{f}	141.4

a, b – means significantly different ($P<0.05$), A, B – means highly significantly different ($P<0.01$)

Conclusions The onset of heat in mares influenced the level of Mg in milk so that mares with earlier heat had lower Mg level in milk. Similarly the length of mares' heat was inversely proportional to the level of Ca and K content so that mares with longer heat produced milk with lower Ca and K level.

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Effects of offering concentrates either before, with or after forage on total tract apparent digestibilities and nutritive values in ponies given either oat straw or grass haylage

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Introduction Most mature horses and ponies in the UK are given restricted amounts of concentrate and forage diets in order to avoid excessive nutrient intake and overfatness, usually in a number of small meals per day. One practical question often asked relates to the timing of concentrate feeding relative to the timing of forage provision. This study's objective was to examine the effects of feeding concentrate meals either before, with or after forage provision.

Materials and methods 6 mature Welsh-cross pony geldings (mean LW 298 kg) were individually housed and used in an eight treatment, 6 x 4 partially balanced incomplete block design experiment consisting of four 21 day periods. Either oat straw (DM: 831, CP: 22, NDF: 884 - treatments 1-4) or grass haylage (DM: 583, CP: 67, NDF: 732 - treatments 5-8) were offered at either 3 kg dry matter (DM) per day (treatements 1 and 5) or 1.5 kg DM/day (treatments 2-4 and 6-8) as the basal forages. The concentrate portion of the diets (DM: 879, CP: 160, NDF: 127) comprised 0.8 micronised wheat and 0.2 mineralised, high protein supplement. Concentrate was either not fed (O) or offered at 1.5 kg DM/day 2 hours before (B), with (W) or 2 hours after (A) the forage portion of diets 2-4 and 6-8 respectively. Meals of either concentrate or forage were offered at either 08:00 or 10:00 hours and at either 15:00 or 17:00 hours. Each 21 day period consisted of a 16 day adaptation and a 5 day recording phase when DM intake (DMI), *in vivo* apparent digestibilities of DM (DMD), organic matter (OMD), CP (CPD), acid detergent fibre (ADFD), NDF (NDFD) and gross energy (GED) along with digestible energy (DE) and digestible CP (DCP) contents were determined. Differences between diets were analysed using residual maximum likelihood (REML) in Genstat 5. *In vivo* apparent digestibilities, DE and DCP contents for the concentrate portion of the diets were estimated "by difference" from total diet values.

Results Concentrate (Conc), forage (For) and total DMIs (Tot) along with total diet *in vivo* apparent digestibilities and nutritive values are given in Table 1. Ponies offered only oat straw consumed less than ($P<0.05$) the intended 3 kg DM/day but all other ponies consumed all feed offered. For all but CP, apparent digestibilities and DE content of oat straw was similar to haylage, perhaps because digesta mean retention time (MRT) within the digestive tract was longer (49 *vs* 33 hrs). Within each forage, no statistically significant differences were seen when concentrates were offered B, W or A forage. Along with the oat straw and haylage values, concentrate *in vivo* apparent digestibilities and nutritive values calculated by difference are given in Table 2. Neither ADFD nor NDFD apparent digestibilities could be calculated for the concentrate portions since fibre from the concentrate contributed only a small proportion of total dietary fibre. DMD, OMD, GED and DE content were all lower ($P<0.05$) when concentrate was given after haylage compared to feeding concentrate with haylage. However, this observation may have simply been a "by difference" calculation artefact due to large variation in haylage MRT between feeding concentrate after (30 hrs) rather than with (41 hrs) haylage. On average, concentrate DE and DCP contents were 14.9 MJ/kg DM and 131 g/kg DM respectively.

Table 1 DMI (kg/d), apparent digestibilities, DE (MJ/kg DM) and DCP (g/kg DM) contents of total diets offered.

	Oat straw				Haylage						Oat straw				Haylage				
(DMI)	O	B	W	A	O	B	W	A	sed	(g/kg)	O	B	W	A	O	B	W	A	sed
Conc	-	1.46	1.51	1.47	-	1.37	1.29	1.43	0.139	DMD	502^{c}	655^{ab}	673^{ab}	689^{a}	469^{c}	618^{ab}	670^{ab}	573^{bc}	50.5
For	2.14^{a}	1.32^{b}	1.25^{b}	1.32^{b}	2.99^{c}	1.55^{b}	1.52^{b}	1.53^{b}	0.182	OMD	500^{a}	675^{b}	682^{b}	699^{b}	480^{a}	638^{b}	688^{b}	587^{ab}	53.1
Tot	2.14^{a}	2.79^{b}	2.76^{b}	2.79^{b}	2.99^{b}	2.92^{b}	2.81^{b}	2.96^{b}	0.223	CPD	-324^{a}	713^{b}	710^{b}	711^{b}	404^{c}	644^{b}	721^{b}	699^{b}	106.7
										ADFD	565^{a}	463^{ab}	430^{ab}	495^{ab}	422^{ab}	328^{b}	430^{ab}	374^{b}	84.0
DE	8.2^{a}	12.3^{b}	11.8^{b}	12.2^{b}	8.0^{a}	11.0^{b}	12.0^{b}	10.0^{ab}	1.15	NDFD	602^{a}	528^{ab}	513^{ab}	555^{ab}	466^{ab}	444^{b}	539^{ab}	455^{b}	67.2
DCP	0^{a}	69^{b}	71^{b}	68^{b}	32^{c}	68^{b}	80^{b}	80^{b}	11.4	GED	455^{a}	640^{bc}	649^{bc}	665^{c}	443^{a}	603^{bc}	655^{bc}	542^{ab}	54.5

Values not sharing common superscripts differ significantly ($P<0.05$).

Table 2 Apparent digestibilities, DE and DCP contents of oat straw, haylage and concentrate calculated by difference.

	Oat straw				Haylage						Oat straw				Haylage				
(g/kg)	O	B	W	A	O	B	W	A	sed		O	B	W	A	O	B	W	A	sed
DMD	502^{ab}	781^{cd}	806^{cd}	847^{cd}	469^{a}	784^{cd}	922^{d}	685^{bc}	94.5	GED	455^{a}	813^{bc}	795^{bc}	840^{bc}	443^{a}	780^{bc}	918^{c}	649^{ab}	105.6
OMD	500^{ab}	837^{cd}	819^{cd}	863^{cd}	480^{a}	810^{cd}	941^{d}	699^{bc}	100.5	DE	8.2^{a}	15.6^{bc}	14.7^{bc}	15.5^{bc}	8.0^{a}	14.4^{bc}	17.0^{c}	12.0^{ab}	2.10
CPD	-324^{a}	858^{c}	848^{c}	837^{c}	404^{b}	741^{c}	885^{c}	839^{c}	108.9	DCP	0^{a}	137^{d}	134^{cd}	133^{cd}	32^{b}	109^{c}	140^{d}	132^{cd}	12.4

Values not sharing common superscripts differ significantly ($P<0.05$) except CPD where ($P<0.01$).

Conclusions Despite some statistical significance in "by difference" calculated figures for concentrate nutritive values, no compelling evidence exists to indicate that feeding concentrates either before, with or after forage has any substantive effect on total tract apparent digestibility or nutritive value in ponies. Further studies are required to examine the pre-caecal digestibility of concentrates when offered at different times in relation to forage provision.

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Benefits of yeast culture supplementation for digestion and milk composition in mares

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Introduction Feeding strategies for performance horses generally involves the substitution of one-two thirds of the fibrous feeds (e.g., forages and pastures) with starchy materials, primarily cereal grains. Such strategies can result in enhanced susceptibility to colic or laminitis (Kronfeld and Harris, 1997) which can be reduced through the use of beneficial microbial combinations that increase nutrient availability, modify gut microflora and enhance performance. One source of microbial live populations is a yeast culture *Saccharomyces cerevisae* (Yea-Sacc ^{1026}; CBS 493.94, *Alltech Inc, USA*) which has been shown to increase the digestibility of gross energy (GE) and enhance the retention of N in yearling horses (Glade and Biesik, 1986), together with enhanced performance. The aim of this review is to determine the effects of *S. cerevisae* on the digestibility of nutrients in the mare, and subsequent effects on milk composition, quality and performance of the offspring.

Materials and methods Studies conducted by Glade (1991a, b, c) involved 8 – 10 pregnant mares fed a diet consisting of 30% timothy hay, 20% alfalfa hay, 17.5% whole corn, 17.5% oats, 9% barley, 2.5% molasses, 2.5% soyabean meal and 1% calcium carbonate. After a 2-week adjustment period to the diets, half of the mares were randomly selected to receive 20 g/day of *S. cerevisiae* from 4 weeks before foaling. After 9 days on the unsupplemented diet, a nutrient digestibility study was conducted via a random sampling acid-insoluble ash indicator ratio method as described by McCarthy et al. (1974). Mid-day milk samples were collected from the mares after 2, 4, 6 and 8 weeks of lactation. The GE content of the milk was determined using a modified procedure of Oftedal et al. (1983), and the amino acid contents of the milk samples were measured by high pressure liquid chromatography (HPLC). Data were analysed by univariate and multivariate analyses of variance for repeated measures experimental designs.

Results Milk intake by foals from yeast-supplemented mares was significantly greater compared with those from unsupplemented mares ($p<0.05$; table 1). Consequently, foals from mares receiving *S. cerevisiae* exhibited greater growth rates and bodyweights at 4 weeks of age ($P<0.01$). In a study conducted by Medina et al. (2002) with mature horses, the supplementation of *S. cerevisiae* to a starchy diet resulted in modified caecal and colonic pH, changed concentrations of lactic acid and ammonia, and molar percentages of acetate and butyrate ($P<0.05$). Additionally, the concentration of total anaerobic and lactic acid-utilising bacteria increased ($P<0.001$), whereas that of cellulolytic bacteria decreased ($P<0.05$) in the cecum. When the digestion of starch in the small intestine was saturated, the effect of the addition of a *S. cerevisiae* preparation appeared to limit the extent of undesirable changes in the intestinal ecosystem of the horse.

Table 1: Milk & nutrient intakes of foals nursing from mares fed with or without supplemental yeast culture (YC; mean ± SEM)

Component	-YC	+ YC
Milk (kg/d)	14.49 ± 0.15a	16.22 ± 0.09b
GE (MJ/d)	2.02 ± 0.19c	2.59 ± 0.16d
Amino acids (g/d)	403.36 ± 10.02a	523.39 ± 9.79b

Means with superscripts are significantly different a, b $P<0.01$; c,d $P<0.05$.

Table 2: Apparent digestibilities of dietary nutrients by mares fed diets with or without supplemental yeast culture (YC; mean ± SEM)

Nutrient	-YC	+ YC
DM	70.3± 1.2^{a}	75.5 ± 3.9^{b}
CP	60.3± 1.2^{c}	65.9 ± 2.4^{d}
ADF	47.5± 2.1	48.5 ± 1.5
NDF	57.3± 1.6^{a}	61.1 ± 1.6^{b}
Calcium	58.7± 0.7	57.8 ± 1.3
Phosphorous	28.2± 1.5^{a}	34.0 ± 1.6^{b}

Conclusions The addition of *S. cerevisiae* to the rations of lactating mares improved feed digestibility, increased milk production, increased the nutrient density of the milk produced and increased the transfer of nutrients to the suckling foal. The results also suggest that these nutrients were absorbed with high efficiency and were processed into body tissues (retained) in greater amounts. The biochemical and metabolic effects of *S. cerevisiae* supplementation of lactating mares were reflected in more rapid rates of gain by their nursing foals. *S. cerevisiae* supplementation can enhance nutrient digestibility and stabilise the caecal and colonic pH, which may contribute to a more stable gut ecosystem, with subsequent improvements in health, lactation and performance of both mares and their suckling offspring.

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Effects of combination of carvacrol, cinnamaldehyde and *Capsicum* oleoresin (XTRACT™ 6930) on the performances of broiler chickens

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Introduction The need for alternatives to the use of antibiotic growth promoters is now well known and accepted by the feed industry. The aim of this experiment was to test the effect of a combination of 5% carvacrol, 3% cinnamaldehyde and 2% *Capsicum* oleoresin, micro-encapsulated in a hydrogenated fat matrix, as an alternative to the use of antibiotics as growth promoters.

Materials and methods 1080 one day old cross Ross male broiler chickens were used for this experiment. Birds were in a floor housing system with 18 pens (replicates) of 20 birds by treatment. Three treatments were tested: a negative control diet containing no additive, a positive control diet (negative control diet + avilamycin at 10g/t) and a combination diet (negative control diet + plant compounds "XTRACT™ 6930" at 75 g/t). At the start of the trial, the broilers had a mean weight of 46.1 grams (s.d. 0.40). Birds underwent routine vaccination against Infectious Bronchitis on day 1 and Newcastle disease on day 14 and no other treatment was necessary. For this trial, a two phase ration diet was chosen: starter from 1 to 14 days and finisher from 15 to 35 days. Both diets were principally based on wheat (46% / 57%), corn (17.6% / 13%) and soybean meal (31% / 23%) respectively. For carcass measurements, a selection of one bird by pen based on the mean live weight of the pen on day 35 was made. The chemical analysis of the different diets gave results that can be considered as identical.

Results Mean weights are given in table 1. Starting weight were not statistically different (P = 0.898). At 35 days, the addition of the above plant compounds in broiler diets gave significantly better final live weight that those given avilamycin at 10 g/t or the negative control diet. First, this improvement in weight gain can be partly explained in this trial by a significant increase in total average feed consumption. Secondly, in the case of the comparison of the avilamycin fed group with the plant compounds fed group, it can be explained by a better feed efficiency. Mortality during this trial was in a normal range and no difference due to the treatments was observed. Some of the carcass results obtained during this trial are summed up in table 2. Plant compounds contained in XTRACT™ 6930 improved numerically dressing percentage when compared to avilamycin group. These plant compounds also increase significantly breast muscle percentage when compared to the negative control group.

Table 1 Mean broiler performance data

Treatment	Negative control	Avilamycin	Plant compounds
Starting weight (g)	46.0^{a} (s.d. 0.38)	46.1^{a} (s.d. 0.44)	46.1^{a} (s.d. 0.38)
Weight at 35 days (g)	1910^{a} (s.d. 285)	2015^{b} (s.d. 310)	2093^{c} (s.d. 305)
Average feed consumption (g/bird)	3017^{a} (s.d. 172)	3318^{b} (s.d. 174)	3384^{b} (s.d. 211)
Feed conversion ratio	1.62^{a} (s.d. 0.09)	1.68^{a} (s.d. 0.05)	1.65^{a} (s.d. 0.09)
Mortality (%)	4.2	3.9	4.8

Mean data not sharing a common superscript are significantly different (P<0.05) according to a Tukey-HDS test

Table 2 Carcass results of 18 selected birds per treatment

Treatment	Negative control	Avilamycin	Plant compounds
Body weight on day 35	1942^{a} (s.d. 91)	2043^{ab} (s.d. 81)	2105^{b} (s.d. 93)
Carcass weight (g)	1280^{a} (s.d 95)	1324^{ab} (s.d. 80)	1382^{b} (s.d. 109)
Dressing percentage	65.9^{a} (s.d. 4.3)	64.8^{a} (s.d. 2.4)	65.6^{a} (s.d. 3.2)
Breast muscle on carcass (%)	23.5^{a} (s.d. 2.1)	24.4^{ab} (s.d. 1.8)	25.1^{b} (s.d. 1.8)

Mean data not sharing a common superscript are significantly different (P<0.05) according to a Tukey-HDS test

Conclusions Both the avilamycin and the plant compound fed groups had significant performance improvement when compared to the negative control group, including final weight and average feed consumption. The plant compound fed group improved numerically the feed conversion ratio when compared to the avilamycin fed group. Both treatments didn't have any influence on mortality and dressing percentage. The body weight and carcass weight were significantly improved by both treatments when compared to the negative control group. A significant improvement on breast muscle percentage was seen only for the plant compound fed group when compared to the negative control group. So this plant compound fed group could then be considered as a real alternative to antibiotic growth promoter.

The effect of feeding fermented wet mash on the gut microbiology of the broiler chicken

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Introduction The control of enteropathogens at farm level is an important aspect of food safety. Contamination of poultry carcasses and eggs with human enteropathogens such as *Salmonella* spp and *Campylobacter* spp and subsequent dissemination through in the food chain continues to be a public health concern. In pigs, surveillance studies have shown that feeding liquid diets, and particularly fermented liquid diets reduces the incidence of *Salmonella* positive herds. Liquid pig feed fermented with lactic acid bacteria for 24 h at 30°C contains *ca* 200 mMol L^{-1} of lactic acid and has a pH of 3.8-4.0. This renders the feed resistant to contamination by potential pathogens and, when challenged with high doses of *Salmonella* or *E. coli* these organisms are rapidly eliminated from the feed (Beal *et al* 2002). Feeding fermented liquid feed (FLF) to pigs lowers the gastric pH to 4 or less, reduces the coliform population and increases the lactic acid bacteria: coliform ratio (LAB: Coli) in the gut (van Winsen *et al* 2001, Scholten *et al* 2002). The objective of this study was to determine if similar beneficial effects on the gut microflora could be achieved in poultry fed fermented mash diets.

Material and Methods Forty five-day old female broiler chicks were randomly allocated to one of three dietary treatments (three pens of 5 chicks per treatment) according to a randomised block design. The dietary treatments were dry pelleted feed, non-fermented wet mash (NFM) and fermented wet mash (FM). Wet mash feeds had a dry matter content of 400 g DM kg^{-1}. NFM diets were sanitized with 300ppm chlorine dioxide immediately prior to feeding. FM diets were inoculated with a freeze dried culture of Bactocell™ and fermented for 24 h at 35°C. All diets were fed *ad libitum.* At approximately 42 days of age two chickens from each pen group (6 per treatment) were slaughtered and the crop, ileum and caecum were removed. Lactic acid and coliform bacteria were enumerated in the gut contents by serial dilution and plating onto de Man Rogosa Sharpe agar (Oxoid Ltd Basingstoke UK) with 0.05% cysteine HCl and 0.01% aniline blue and MacConkey agar (Oxoid Ltd) respectively. LAB and coliform counts and LAB:Coli were $\log_{10}$ transformed prior to statistical analysis (Anova) using Minitab v.1332. Samples of gut and gut contents (25g) were added to selective enrichment media (tetrathionate broth and Campylobacter enrichment broth) for the detection of *Salmonella* spp and thermophilic Campylobacters. After incubation for 48 hrs enrichment broths were plated onto XLD and Brilliant green agar (Oxoid Ltd) for the detection of *Salmonella* spp and *Campylobacter* selective media (Oxoid Ltd) for the detection of campylobacters. Identification of presumptive positive colonies of *Salmonella* and *Campylobacter* were confirmed by serological tests.

Results LAB counts in FM were *ca*. 10^9 c.f.u. ml^{-1} and remained consistent over the duration of the trial. The mean lactic acid concentration of FM was 115 ± 26 mM and pH 3.9 ± 0.2. Broilers fed FM had significantly ($P < 0.05$) higher LAB:Coli ratios in the ileum and caecum than birds fed NFM or dry feed (Figure 1). Coliform numbers were significantly reduced in the ileum of broilers fed FM (1.4×10^3 cfu ml^{-1}) compared with those fed NFM (2.9×10^5 cfu ml^{-1}) or dry feed (7.2×10^6 cfu ml^{-1}). In the caecum, coliform numbers in birds fed FM remained an order of magnitude lower (4.6×10^8 cfu ml^{-1}) than those fed NFM or dry feed (ca. 10^9 cfu ml^{-1}). Of the six birds examined per treatment two fed dry feed and one fed NFM were *Salmonella* positive. No *Campylobacter* was isolated from any of the birds.

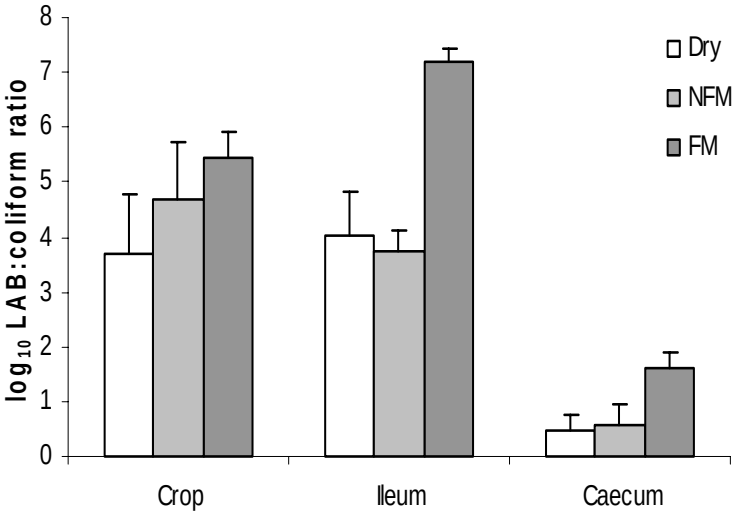

Figure 1 LAB: Coli ratio in the crop, small intestine and caecal contents of broilers fed dry feed, fermented mash (FM) or non-fermented mash (NFM)

Conclusions This study showed that fermented feed had a beneficial effect on the microflora of the gut in broilers. Despite the high numbers of LAB ingested daily by birds fed FM the increase in LAB:Coli ratio in the ileum was due to depression of the coliform population rather than an increase in LAB populations. The absence of *Salmonella* in birds fed FM compared with those fed dry feed and NFM suggest that this area warrants further study.

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Active yeast to reduce hepatotoxity induced by aflatoxins

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Introduction The yeast are plenty biological agents known by their participation in the elaboration of several products of human interest, obtained through biotechnological processes. In animal production, its use is recommended as a probiotic, which seems to improve the use of the foods and promote a better balance of the gut microflora. On the other hand, aflatoxicosis are diseases caused by intake of feed contaminated with aflatoxins, which can result in reduction of the animal performance and can promove serious problems of public health. Recently, research has indicated results encouraged to use yeast to control of aflatoxicosis. By these reasons, the aim of this work was to evaluate the capacity of different concentrations of the *Saccharomyces cerevisiae* strain Y1026, active, to reduce the induced damages by ingestion of different levels of aflatoxins under different times of exposition.

Material and methods Two bioassays in randomized designing were carried out using Wistar rats, of 21 days of age and 50 grams of live weight. Each treatment had four replication. The first assay was lead by a period of 30 days and the second assay was carried out by a period of 60 days. The evaluated treatments were obtained from a basal diet, as described by Reeves et al. (1993) (Table 1). For the evaluation of the effect of the treatments the animal hepatic tissue was collected and submitted for histopathologic analysis. Analysis of aflatoxins were carried out according by Soares and Rodrigues (1989) and the viability to cellular of yeast was did by method of coloration with blue of methylene, as described by Pierce (1970).

Table 1 Description of the evaluated treatments.

Treatments	Description of the treatments	Treatments	Description of the treatments
T1	Basal diet free aflatoxins	T6	Basal diet free aflatoxins
T2	T1 + 400 ug kg^{-1} of aflatoxins	T7	T6 + 550 ug kg^{-1} of aflatoxins
T3	T2 + 0.5% of yeast	T8	T7 + 0.5% of yeast
T4	T2 + 1.0% of yeast	T9	T7 + 1.0% of yeast
T5	T2 + 5.0% of yeast	T10	T7 + 5.0% of yeast

Results The results obtained at the first assay demonstrated that the hepatic tissue of the animals submitted to the treatment T2 showed evidents signals of hepatotoxity, with great disorganization and cellular necrosis. The animals submitted to the treatments T3, T4 and T5 presented few signals of cellular damages, differing from those observed in the animals of the T2 group and its results were similar to the results observed in the animals of T1 group (Table 2).
In the second assay, through the histopathologic analysis, it can be observed that the animals submitted to the treatment T7 presented great disorganization and necrosis of the hepatocits. The animals submitted to the treatment T7 presented similar symptoms of toxicity to those observed by the T7 group. On the other hand, the animals of the T9 group showed reduction in the hepatotoxity, however, they had yet presented disorganization and cellular necrosis. The animals submitted to the treatment T10 presented great reduction of the damages caused by aflatoxin ingestion and they demonstrated similiar to the aflatoxin-free control (Table 2).

Table 2 Results of hepatotoxity observed in the animals.

Treatments	Signs of hepatotoxity observed		Treatments	Signs of hepatotoxity observed	
	Cellular disorganization	Cellular necrosis		Cellular disorganization	Cellular necrosis
T1	-	-	T6	-	-
T2	+ + + +	+ + + +	T7	+ + + + +	+ + + + +
T3	-	-	T8	+ + + + +	+ + + + +
T4	-	-	T9	+	+
T5	-	-	T10	-	-

+ indicate the presence of the characteristic ; - indicate the absence of the characteristic

Conclusions The concentration of yeast applied had decisive role at the efficiency of control of aflatoxicosis. The ability of yeasts to minimize aflatoxicosis is influenced by level of contamination and the time of exposition to aflatoxin.

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A comparison of the effectiveness of three substitute colostrums fed to lambs

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Introduction Colostrum is essential for the newborn lamb as it provides nutrients for energy and heat production and passes on disease immunity in the form of immunoglobulins (IgG). Without colostrum in the first few hours of life the lamb would be at great risk from hypothermia, starvation and septicaemia (Binns *et al*, 2002). Ewes are sometimes unable to provide their lambs adequate colostrum so there is always a need for substitutes. There are many substitute colostrums available and the aim of this trial was to compare three, hyperimmune bovine colostrum, caprine colostrum and an artificial colostrum as a positive control. CO-LATE Ultra Concentrate whole colostrum supplement for lambs (Net-tex Agricultural Ltd) which is manufactured from whole cow colostrum was selected as the positive control as it was found to be most widely used and of average price. Caprine (goat) colostrum has not been widely researched for use with lambs although it is similar in composition to ewe colostrum which may make it more beneficial than artificial colostrums.

Materials and methods Two studies were carried out and the lambs in both study were sets of triplets, one from each triplet was allocated to a different treatment group at birth. The three treatment groups received colostrum from a different source, either cow, goat or artificial colostrum. Study 1 involved 66 lambs that were given one dose of colostrum at birth via stomach tube. Recordings were taken for each lamb; recovery time (time taken for lamb to suckle after receiving one dose of artificial colostrum), mass of lamb at birth, 24 hours and 1 week, mortality and disease. In study 2, 30 lambs were given a dose of colostrum at birth and kept from suckling from the mother until 6 hours. The ewe could still touch, see and hear her lambs. Blood samples were taken at 2 and 6 hours old to record gammaglobulin and glucose concentrations. Lambs were given a second dose of colostrum at 2 hours. Mortality, disease and mass of lamb at birth and 24 hours were recorded. Normally distributed data was analysed with ANOVA and significant differences were examined further with Fishers post-hoc test.

Results There was no significant difference ($P>0.05$) in recovery times between the three treatments with all treatments having a mean recovery time of over 40 minutes. Lambs given goat colostrum had a higher but not significant mean weight gain of 0.18kg at 24 hrs compared to lambs fed either cow (0.08kg) or artificial (0.08kg) colostrum. Lambs given hyperimmune cow colostrum showed the highest mean weight gain in week 1 of 1.67kg although it was not significant. Glucose concentrations in the blood, Fig. 1, were noticeably different between 2 hours and 6 hours after feeding for each treatment. There was a significant difference ($P<0.05$) between the three treatments after 6 hrs and Fishers test showed the difference to be in the artificial colostrum fed lambs which had the highest concentration of glucose in the blood. Gammaglobulin concentration in the blood, Fig. 2, was not significantly different after 2 hours although after 6 hours hyperimmune cow colostrum showed a significant difference, $P<0.05$ from the other two treatments. There was no significant difference in mortality or disease between the groups.

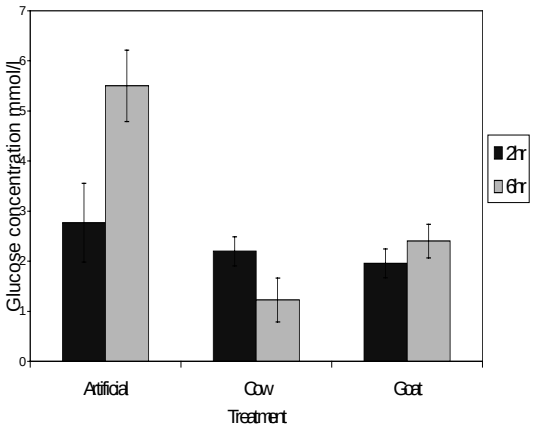

Figure 1. Mean (±se) glucose levels in lambs blood

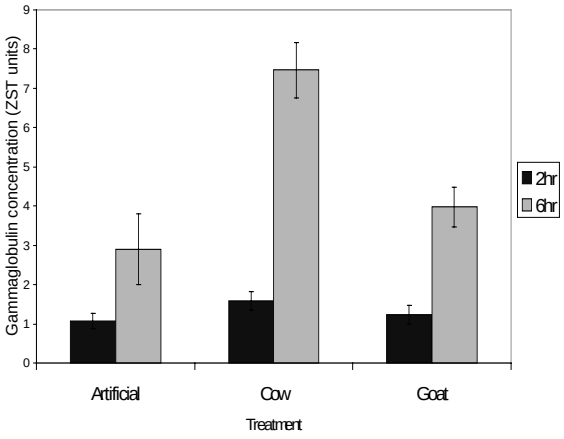

Figure 2. Mean (±se) gammaglobulin levels in lambs blood

Conclusions Lambs fed artificial colostrum had significantly higher blood glucose levels after 6 hours (Fig.1). The hyperimmune cow colostrum was found to pass significantly higher amounts of gammaglobulin to the lamb at 6 hours after birth than either of the other two treatments (Fig.2). Artificial colostrum may be lacking in the disease protection of lambs which suggests that it shouldn't be relied upon as the only source of colostrum for a lamb. Further work should be carried out on the hyperimmune colostrum to investigate thoroughly its potential benefits.

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Supporting natural defence mechanisms against bacterial infection in the urogenital tract of sows via dietary means to minimise the use of antibiotics

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Introduction Reproductive failure accounts for substantial losses in the swine industry worldwide. Examinations of reproductive organs of sows culled for infertility showed that one of the most important causes of reproductive failure are urogenital tract infections (UTI) caused by uro-pathogenic bacteria (Wegmann 1993). Prevalence of UTIs ranges from 4 to 20% in sow herds, but can reach up to 45% in problem herds (Both *et al.* 1980) and are a predisposing factor to Mastitis-Metritis-Agalactia syndrome. A decrease in urinary pH, is one of the natural defence mechanisms against bacterial proliferation in the uro-genital tract (Arnhofer 1986). Therefore down-regulating the urinary pH via dietary means could be used as a prophylactic measure against urinary tract infections in sow herds. The objective of this experiment was to test a dietary urine acidifier based on anionic substances and plant extracts for the effect on urinary pH in sows.

Materials and methods A total of 29 Landrace x Large White breeding sows were split into two groups at d107 of pregnancy. The control group was fed conventionally and the trial group received the dietary urine acidifier Biomin® pHD based on phosphoric acid and cranberry extract (min. 330g/kg and 40g/kg respectively) as a top dressing to the diet at 15g/d/sow from day 108 of pregnancy until re-breeding. Lactation length (28 days), environment and management practices were standardised for all groups. Measurements included sow urinary pH and MMA incidence. Urinary pH was measured at day 108 of pregnancy, one day post farrowing and at one day post insemination in all sows. All urine samples were collected in the morning between 7 and 8 am before feeding. The urinary pH was measured with a pH meter (Checker® 1, Hanna Instruments) in samples taken from the mid stream urine. Data were analysed by one-way analysis of variance using dietary treatment as a factor (Minitab, version 12.2). Urinary pH prior to treatment was used as a covariate in analysis of urinary pH changes.

Results At the beginning of the trial the overall mean for the urinary pH in sows was 6.8 (±0.119 SEM) and similar for both groups (Table 1). Urinary pH was decreased in both groups at farrowing and at insemination compared to d108 of pregnancy. However the decrease in urinary pH was significantly higher ($P<0.05$) in the trial group, when corrected for the pH at the beginning of the trial. The urinary pH in response to feeding Biomin® pHD was significantly ($P<0.05$) lower than 6.5, which has been associated with decreased bacterial counts in urine in previous studies (Arnhofer 1986). The use of Biomin® pHD was associated with a numerical decrease in the incidence of MMA cases (1/14 v 6/15).

Table 1 Urinary pH in response to a dietary urine acidifier in breeding sows

	Control	Biomin® phD	P-value	SED
No.of sows	15	14		
Parity	5.2	4.9	0.785	1.247
pH1 d108 pregnancy	6.9	6.7	0.610	0.241
pH2 farrowing	6.4	6.0	0.050	0.165
pH3 insemination	6.5	6.2	0.014	0.122
pH2-pH1	-0.5	-0.7	0.299	0.203
pH2-pH1*	-0.5	-0.8	0.048	0.140
pH3-pH1	-0.3	-0.5	0.498	0.254
pH3-pH1*	-0.2	-0.6	0.020	0.122

*adjusted for pH1

Conclusion Biomin® pHD helps the user in formulating the diets of breeding sows in terms of decreasing the urinary pH, thus supporting the natural defence mechanisms against UTI at reproductive stages, where the risk for developing metritis is greatest (farrowing and insemination). Further investigations on the effect of dietary urine acidification on sow fertility parameters are required.

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Immunomodulatory effects of supplementing animal feed with mannan-oligosaccharides: a review

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Introduction. Mannan-oligosaccharides (MOS) have been used as animal feed supplements to maintain productive performance over the past decade (Hooge, 2003). In recent years new monogastric diseases have emerged, many which have been linked to inadequacies in the immuno-competence of young and fast growing animals and compromise growth. The ability of certain MOS to bind pathogens bearing type 1 fimbrae is well documented (Newman, 1994). When MOS binds pathogens to its surface and interacts with the gut wall, the 'presentation' of agglutinated bacteria to immune-specific sites can lead to more efficient and targeted response to pathogens. This paper reviews the trials measuring immune parameters conducted using MOS (Bio-Mos™, Alltech Inc, USA) in poultry and pig diets.

Material and methods. Trials measuring immune parameters in poultry and pigs were selected from MOS trials conducted in institutes in Europe, Asia and USA. The first broiler trial (Cotter & Weinner, 1997) investigated inflammatory response. Caged broilers were fed commercial diets with or without 1 kg/t MOS supplementation from 0-10 weeks, and were injected with phyto-haemagglutinin into the wattles. After 24 hours the thickness of the wattle was used as a measure of inflammation. A vaccine trial was conducted in Hungary (Korosi & Korosi-Molnar, 2003) using 600 Ross broilers in a replicated pen trial (50 birds x 6 replicates) on used litter, and fed either a control or MOS diet (2 kg/t starter, 1 kg/t grower, 0.5 kg/t finisher). Newcastle vaccination efficacy (by spray at day old and via water at 21 d) was measured at 42 d. A USA turkey trial (Savage et al, 1996) compared benefits of MOS in eight week old Wrolstad medium turkeys fed a control diet or 1 kg/t MOS in feed. At 53 d.o. blood and bile samples were taken and analysed for immunoglobulins (Ig) IgG and IgA by rocket immuno-electrophoresis, expressed as arc height for the precipitin on the electrophoretic gel. Several pig trials have been carried out investigating immunity benefits in sows, piglets and growing pigs. A trial at the University of Kentucky (Newman & Newman, 2001) used 24 sows split between a control and MOS treatment (5g/h/d) and monitored colostrum Ig level and piglet weight until weaning (21d). Immunity was specifically measured in piglets in a trial run at the Pasteur Institute (Privulescu, 1999). Piglets were fed diets containing either control or MOS (1 kg/t) over a 60 d period from weaning. Ig in bile, digesta and blood and lymphocyte levels was measured at 60 d. Coliform scour problems were investigated in a trial in China (Xiao-Hong, 1999). Four groups of 20 piglets were fed control or MOS supplemented feeds (250 mg/h/d), and diarrhea incidence and total serum protein (as indicator of Ig levels) was recorded at weaning (20d). Recent trials have examined effects of MOS on lymphocyte proliferation in weaning piglets (Davis & Maxwell, 2003) where eight pens of 2 piglets per treatment were fed control versus MOS diets. Blood taken at 33 d was analysed for immune cell levels (as relative proportions in blood). Phagocytotic activity in jejunal tissue was measured by lysis of sheep red blood cells (SRBC). All data was analysed by GLM procedure of SAS where applicable.

Results. Significant changes in inflammation response, vaccine efficacy and Ig levels were observed in broilers and turkeys fed MOS diets. Farrowing sows receiving MOS had significantly increased Ig levels in colostrum, and produced heavier piglets at weaning. Weanlings fed MOS showed less coliform scours and increased immune function. Ig level and activity was also significantly higher in growing pigs raised on MOS-supplemented diets.

Table 1: Immune responses observed in poultry fed MOS-supplemented diets (superscript denotes reference source)

	Wattle thickness (%)[1]	ND vaccine failure(%)[4]	Bile IgA (mm)[9]	Plasma IgG (mm)[9]
Species	Broiler	Broiler	Turkey	Turkey
Age/time	10 weeks	6 weeks	8 weeks	8 weeks
Control	217	27	7.6	7.6
Bio-Mos	167	0	9.1	9.9
P value	0.01	NA	0.007	0.0001

Table 2: Immune responses observed in pigs fed MOS-supplemented diets (superscript denotes reference source)

	Colostrum IgM (mg/dl)[7]	Body weight[7]	Diarrhoea incidence (%)[10]	Total serum protein (g/dl)[10]	Lymphocyte level (%)[2]	Jejunal phagocytosis(%)[2]	Digesta IgA (Opt. density)[8]	Total IgG (mg/100ml)[8]
Type	Sows	Piglets	Piglets	Piglets	Piglets	Piglets	Grower	Grower
Age/time	Farrowing	21d	20 d	20 d	33d	33d	60 d	60 d
Control	316	6.57	41	4.88	42.8	2.31	723	2026
Bio-Mos	440	7.61	25	5.28	50.7	2.63	899	3648
P value	0.037	0.011	-	<0.1	0.08	<0.05	>0.05	>0.05

Conclusions Both pigs and poultry fed diets supplemented with MOS showed increased immune responses and improved efficiency of coping with stresses such as inflammation and scouring. Such responses confirm that improvements in presenting pathogens active in the animal can increase the immune response, resulting in correct defence against a disease or faster recovery from the infection.

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Innate immunocompetence status in indigenous poultry of A & N Islands

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Introduction The indigenous poultry germplasm of Andaman & Nicobar Islands includes Nicobari fowl, Barred desi, Naked neck and Frizzle fowl, of which Nicobari fowl is the only native fowl of these Islands. The study of immune status is indirectly correlated with the disease resistance characteristics of the bird's .The present study was conducted to know the primary humoral antibody response to Sheep RBC (SRBC) and their persistence in the immune system. However, for complete immunocompetence status, beside humoral responses the CMI and phagocytic responses are also to be considered.

Materials and methods The adult Nicobari fowl (White, Black & Brown), Naked neck, Barred desi, Frizzle fowl and White leghorn were selected for the study. Ten birds of either sex from each group were selected and kept in individual cages throughout the experiment. Each bird was inoculated with 0.25 ml of 2% SRBC (Sheep RBC) through I/V route. The blood samples were collected from all the birds at 0, 5, 10, 14 days and at weekly interval upto 10^{th} week from the date of inoculation. The antibody titer in the serum to SRBC was assessed by employing Haemagglutination (HA) and 2-mercaptoethanol-sensitivity test using 2% SRBC suspension as antigen (Siegel and Gross, 1980). The titer was expressed as the log2 of the reciprocal of the highest dilution giving visual agglutination (button formation). All the data were analyzed statistically. The titers were evaluated by analysis of variance with breed X day's interaction.

Results The means along with standard errors for antibody response (HA titre) are given in Table 1. The results revealed the appearance of antibody in all the birds on 5^{th} day of immunization. The HA titre values in all the indigenous birds were found to be relatively higher than White Leghorn. The antibody titre reached its peak at 10^{th}-28^{th} day PI and the response did persist for 10^{th} week PI. The peak log2 titre of the Brown Nicobari fowl was found to be highest among all the birds with peak value of 4.75± 0.75 at 14^{th} day. The peak log 2 titre of the birds in decreasing order observed were Barred desi (3.75± 0.85) at 14^{th} day, Black Nicobari (3.5± 0.29) at 10^{th} day, Naked neck (2.75± 1.11) at 35^{th} day PI, White Nicobari (2.5± 0.65) at 10^{th} day PI, Frizzle fowl and White Leghorn (1.75± 1.03) at 10^{th} day PI respectively. Statistical analysis revealed the significant difference ($P<0.05$) of the HA value at different days of antibody titer in the entire group. The interaction between all the breeds was also found to be significant ($P<0.05$) at different days intervals of antibody titre.

Table 1 Means and standard errors of HA titer (log2) of different genotypes

Genotypes	Days post immunization											
	5	10	14	21	28	35	42	49	56	63	70	M ± SE
Black Nicobari	3.25± 0.75	3.5± 0.29	1.75± 0.25	3.0± 0.71	1.5± 0.5	0.5± 0.29	0.25± 0.25	2.25± 0.25	2.0± 0.58	1.5± 0.29	1.0± 0.41	1.86± 0.20 ^{c}
White Nicobari	2.0± 0.41	2.5± 0.65	1.0± 0.71	2.0± 0.71	2.25± 0.25	0.75± 0.25	0.25± 0.25	1.25± 0.48	1.25± 0.48	0.25± 0.25	0.75± 0.75	1.29± 0.20 ^{cd}
Brown Nicobari	1.5± 0.29	4.0± 0.71	4.75± 0.75	4.5± 0.5	4.75± 0.25	4.0± 0.41	4.25± 0.63	3.75± 0.48	4.0± 0.41	2.75± 0.48	1.0± 0.58	3.57± 0.23 ^{a}
Barred desi	2.0± 0.41	3.0± 0.41	3.75± 0.85	3.25± 0.85	3.0± 0.41	3.25± 0.48	3.0± 0.00	2.5± 0.29	1.5± 0.29	0.00	0.00	2.29± 0.22 ^{b}
Naked neck	0.5± 0.29	0.5± 0.29	0.5± 0.5	0.25± 0.25	2.5± 0.29	2.75± 1.11	2.5± 0.65	2.5± 0.29	2.5± 0.87	1.25± 0.95	0.75± 0.75	1.50± 0.23 ^{c}
Frizzle fowl	3.75± 0.48	1.5± 0.29	1.75± 1.03	1.75± 0.85	1.5± 0.65	2.0± 0.71	1.5± 0.65	1.25± 0.48	0.5± 0.29	0.5± 0.5	0.00	1.45± 0.21 ^{c}
White Leghorn	3.75± 0.48	1.5± 0.29	1.75± 1.03	1.75± 0.85	1.5± 0.65	2.0± 0.71	1.5± 0.65	1.25± 0.48	0.5± 0.29	0.5± 0.5	0.00	1.59± 0.24 ^{c}
M ± SE	1.85 ± 0.27 ^{c}	2.42 ± 0.31 ^{ab}	2.25± 0.39 ^{ab}	2.89± 0.35 ^{a}	2.93± 0.30 ^{a}	2.21± 0.35 ^{ab}	2.04± 0.36 ^{b}	2.36± 0.23 ^{ab}	2.21± 0.31 ^{ab}	1.43± 0.25 ^{cd}	0.71± 0.19 ^{d}	

Mean having the common superscript in the row and column do not differ significantly ($P<0.05$).

Conclusions The overall study revealed that Brown Nicobari fowl is better than other indigenous birds in eliciting immune response. It can be concluded that the indigenous poultry germplasm elicited relatively higher immune response to SRBC while significant variation was observed among the different genotypes with respect to their antibody response on the different days post immunization.

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The effect of zinc oxide and *Enterococcus faecium* SF68 dietary supplementation on the performance and immune response of weaned piglets.

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Introduction The impending EU-wide ban on the use of antibiotic growth promoters (AGP), and potential legislation over the use of zinc oxide (ZnO), necessitates the need to find credible alternatives. Zinc oxide has proven to be effective at promoting post-weaning growth and reducing the incidence of diarrhoea, although its mode of action remains unclear. The use of probiotics is often proposed as an alternative, but their efficacy remains unpredictable and unproven. Probiotics do, however, have the potential to modulate the gastrointestinal microbiota and immune response (Perdigon *et al.*, 1995). This experiment aimed to investigate whether dietary supplementation with ZnO and a recognised and characterised probiotic strain would enhance post-weaning piglet performance in the absence of AGP.

Materials and methods Two hundred and eight crossbred piglets (JSR Healthbred) were weaned at, 22.9 ± 3.6 days of age (± SEM) and 6.8 ± 0.76 kg liveweight, into commercial flatdeck accommodation. Six or 7 piglets were allocated to each pen (1.99m^2) on the basis of liveweight, litter origin and gender. Pens were randomly allocated to a 2 x 2 factorial experiment involving two levels of zinc oxide supplementation (0 or 3100 mg ZnO/kg feed), and two levels of *Enterococcus faecium* SF68 supplementation (0 or 1.4 x 10^9 CFU/kg feed (Cylactin ME10)). All diets were formulated to contain 16.8 MJ DE/kg, 17.0 g total lysine/kg from weaning to day 7, and 15.5 MJ DE/kg, 15.5 g total lysine/kg between days 8 and 20. All diets and drinking water were provided on an *ad libitum* basis. Piglets were tagged and individually weighed at weaning and on day 20 post-weaning. Daily feed intake per pen was recorded between weaning and day 20. Eight piglets from each treatment group were slaughtered on day 20 post-weaning. Blood and intestinal tissue samples were obtained to determine serum IgG and intestinal IgA concentrations. Data were analysed using the GLM procedure of Minitab 12.2.

Results Pig performance is shown in Table 1. Between days 1-20, ZnO supplementation resulted in a numerically higher daily consumption of feed (335.4 g/p/d vs. 312.0 g/p/d) and weight gain (289.4 g/p/d vs. 264.9 g/p/d) by the piglets, although these differences were not significant. Similarly, ZnO supplementation resulted in a lower FCR, but the difference was not significant. Dietary ZnO concentration did not affect serum IgG concentration, but ZnO supplementation tended to increase intestinal IgA concentration on day 20 (57.78 μg/g wet tissue vs. 39.90 μg/g wet tissue) ($P<0.1$). Probiotic supplementation did not offer any benefit to the pigs in terms of performance. Probiotic supplementation, however, tended to decrease day 20 serum IgG concentration (4.55 mg/ml vs. 6.07 mg/ml) ($P<0.1$), but intestinal IgA concentrations were similar. There were no interactions between main effects.

Table 1 Day 1-20 average daily feed intakes (FI, g/pig/day), average daily liveweight gains (ADG, g/pig/day), feed conversion ratio (FCR) and day 20 serum IgG and intestinal IgA concentrations.

	Zinc oxide (ZnO)		*Enterococcus faecium* (EF)					
D 1-20	0	3100 mg/kg	0 CFU/kg	1.4x10^9 CFU/kg	SEM	ZnO	EF	ZnO*EF
FI	312.0	335.4	321.0	326.3	10.93	NS	NS	NS
ADG	264.9	289.4	276.6	277.7	10.37	NS	NS	NS
FCR	1.19	1.16	1.17	1.18	0.02	NS	NS	NS
Serum IgG (mg/ml)	5.14	5.48	6.07	4.55	0.58	NS	0.077	NS
Intestinal IgA (μg/g wet tissue)	39.90	57.78	50.66	47.02	6.88	0.077	NS	NS

NS, non-significant

Conclusion The results suggest that ZnO supplementation may stimulate IgA synthesis within the intestine. The surprising lack of a significant growth response to ZnO supplementation may indicate that the experimental conditions failed to compromise piglet gut health sufficiently. No performance benefit was observed due to probiotic supplementation, although it may reduce serum IgG synthesis. This could be due to a direct immunomodulation effect by the probiotic or indirectly by reducing the translocation of bacteria or bacterial products from the gastrointestinal lumen to the systemic circulation. To fully evaluate the potential efficacy of probiotics, it may be necessary to pay greater consideration to the choice of probiotic, as well as, the method and timing of administration.

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The effect of supplementing the neonatal diet with palm or soya oil on piglet growth performance

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Introduction Early nutrition of the neonatal pig has a major impact on its survival and subsequent development (Cieslak *et al.*, 1983). The success of maternal nutrition trials has been limited in improving the survival and growth performance of piglets. Milk yield and composition has been altered (Jackson *et al.*, 1995; Averette *et al.*, 1999), which subsequently enhanced piglet health and growth performance but feeding supplemental fat had little or no effect on the birth weight of piglets. The aim of this study was to examine the effect of supplementing palm and/or soya oil directly to the piglet on its subsequent growth performance.

Materials and methods Our previous studies have demonstrated that during the first 2 weeks of life a piglet consumes on average 2.99MJ/day in the form of milk, which is a similar value to that quoted by Pluske *et al.* (1995). At birth thirty-two piglets entered the trial and were randomly allocated to one of 4 treatments as follows: (i) placebo (P; n=8) or 30% extra energy derived from (ii) palm oil (PO; n=8), (iii) soya oil (SO; n=8)or (iv) 50:50 mixture of PO:SO (M; n=8). Piglet body weight, crown-to-rump length (CRL), abdominal circumference (AC), girth (G)) and an estimation of fat free mass (FFM) using a TOBEC analysing system (Bellinger and Williams, 1993) were recorded at 0, 7 and 14 days of neonatal life. The fat-free mass (FFM) was estimated using the following equation:

$$\sqrt{(\text{TOBEC reading} * \text{CRL})}$$

Results At birth there were no differences in body weight, CRL, AC, girth and FFM. Supplementing the diet with SO had a detrimental influence on weight gain, and consequently by day 7 and 14 of life SO piglets were lighter ($P<0.05$) and had a reduced ($P<0.05$) FFM than the P group (Table 1). In addition, AC and was smaller ($P<0.05$) on day 7 in SO compared to all other groups.

Table 1 Body weight, abdominal circumference (AC) and fat free mass (FFM) for each treatment group

	P (n=8)	PO (n=8)	SO (n=8)	M (n=8)
Body weight d7 (kg)	2.79±0.16 [a]	2.67±0.16	2.05±0.17 [a]	2.48±0.16
Body weight d14 (kg)	4.44±0.43 [a]	3.99±0.44	2.64±0.50 [a]	3.52±0.44
AC d7 (cm)	25.8±1.0 [a]	25.3±1.0 [b]	21.1±1.0 [abc]	25.4±1.0 [c]
FFM d7 (arb. Units)	192±10 [a]	179±10	145±11 [a]	169±10
FFM d14 (arb. Units)	228±26 [a]	239±26	172±30 [a]	220±26

Values are presented as means±SEM. Mean values within each row with a common superscript letter differ significantly: a, b, c $P<0.05$.

Conclusions The addition of soya oil to neonatal piglet diets had a marked detrimental effect on piglet growth performance. These effects may in part be due to the occurrence of hypersensitivity reactions similar to those observed in weaned pigs fed soya as a protein source (Li *et al* 1990).

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The effects of hops in weaner pig diets of different energy levels

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Introduction The current use of antibiotics in weaner pig diets is likely to be banned from 2006, and alternatives are sought to improve growth and health status of weaner pigs. Hops (*Humulus lupulus* L.) are mainly known from the brewing industry, but they are also known for their antimicrobial activity and antioxidant properties (Stevens *et al.*, 1998). Hops may be a suitable alternative to antimicrobial growth promoters, particularly when pigs are not able to maximise their growth potential, for example when fed low density rations. The objective of the trial was to investigate the effects of hops on newly weaned piglets on growth performance, liver function and microbiology in diets of different nutrient density.

Materials and methods 128 (PIC Camborough 15) weaner pigs were selected at 28 days of age at Harper Adams University Pig Unit. The pigs were randomly allocated to one of four treatments with eight replicates of four pigs per pen in a 2x2 factorial design. The treatments were: a control diet with no additives and the same diet with 1 kg/tonne of hops. These were at two density levels a standard level (S) and a diluted (D) with 10% oat hulls. A weaner diet (S: DE 17.1 MJ/kg, CP 236g/kg, D: DE 16.3 MJ/kg, CP 233g/kg) was fed from day 0 to day 11, and a link diet from day 11 to 28 (S: DE 16.6 MJ/kg, CP 244g/kg, D: DE 15.8 MJ/kg, CP 235g/kg). The pigs were housed in fully slatted environmentally controlled flatdecks throughout the experiment. Diets and water were available *ad libitum*. Live weight and feed intake were measured at weaning, day 4 and day 11 post weaning and thereafter at weekly intervals. Faecal samples were assessed at weaning, day 11 and day 28 on a scale from 1 to 5, with 1 being severe diarrhoea and 5 a hard consistency. Faecal samples were taken and stored at -80˚C on day 11 and 28 to determine the number of *Escherichia coli*. Blood samples were collected on days 7, 18 and 27, these were analysed for the liver enzymes aspartate aminotransferase (AST), alanine aminotransferase (ALT) and gamma-glutamyl transpeptidase (GGT) as well as direct and total bilirubin (all Randox). Statistical analysis was carried out using ANOVA (GENSTAT 5).

Results There were no significant differences in growth rate at any time. The FCR was significantly lower for the control diets and diluted diets in the period from day 0 to 11 after weaning. However, in the second period from day 11 to day 28, the hops showed significantly lower FCR and the dilution of the diet resulted in a significantly higher FCR due to the diluted control diet. The faecal score at weaning was used as a covariant in the analysis for day 11 and 28. The faecal score was higher for the pigs given the diluted diets on day 28. There was a positive association between the faecal score on day 11 and the daily live weight gain over 7 days prior to faecal sampling day 4 to 11 (R^2 11.8, p=0.031). The *E. coli* numbers were lower on day 28 than on day 11 for 3 of the diets. No correlation between *E. coli* number and faecal score was seen. No significant differences were seen in liver enzymes on day 7 and 18. AST was significantly lower for the hops treatments on day 27, and there was a trend for the ALT treatment to be lower for the hops treatment on day 27, indicating hops may have potential beneficial effects on the liver enzymes. There were no significant differences in total and direct bilirubin.

Table 1 Effects of hops in diets of different density level on the performance, faecal score and level of liver enzymes in weaner pigs.

Diet density	Standard		Low			Significance		
Hops inclusion	-	+	-	+	s.e.d.	Hops	Density	Hops x Den.
Gain day 0-11 (kg/day)	0.21	0.17	0.20	0.20	0.020	ns	ns	ns
Gain day 11-28 (kg/day)	0.51	0.50	0.48	0.53	0.033	ns	ns	ns
FCR 0-11	1.33	1.53	1.26	1.31	0.066	0.017	0.006	ns
FCR 11-28	1.46	1.46	1.65	1.46	0.060	0.028	0.040	0.037
E. coli day 11 (cfu/ml)	$3.7x10^5$	$17.0x10^5$	$17.2x10^5$	$13.4x10^5$	$8.9x10^5$	ns	ns	ns
E. coli day 28 (cfu/ml)	$5.0x10^5$	$1.4x10^5$	$1.0x10^5$	$1.0x10^5$	$2.1x10^5$	ns	ns	ns
Faecal score day 0	4.3	4.0	4.2	4.0	0.193	0.079	ns	ns
Faecal score day 11*	3.1	2.8	3.2	2.8	0.252	0.069	ns	ns
Faecal score day 28*	2.9	2.8	3.5	3.3	0.275	ns	0.021	ns
AST day 27 (mmol/l)	50.3	40.2	52.3	40.1	5.38	0.005	ns	ns
ALT day 27 (mmol/l)	45.3	40.8	46.6	43.4	3.20	0.092	ns	ns
GGT day 27 (mmol/l)	22.3	24.6	23.5	21.4	2.34	ns	ns	ns

* faecal score day 0 used as covariant, AST = aspartate aminotransferase, ALT = alanine aminotransferase, GGT = gamma-glutamyl transpeptidase

Conclusions The results show that inclusion of hops in weaner pig diets may have potential beneficial effects on FCR and liver function. Furthermore, dilution of diets resulted in a lower level of diarrhoea at day 28. This indicates there might be beneficial health effects of having lower density diet for weaner pigs.

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The effect of supplementing the maternal diet with palm or soya oil during late gestation on piglet growth performance

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Introduction A substantial and continual economic loss within the pig industry is the 5-20% pre-weaning mortality rate that occurs during the neonatal period (MLC, 2002). The principal causes of piglet death are low birth weight in conjunction with insufficient amounts of body fat reserves (Herpin *et al.*, 1993; Varley, 1995). Studies by Rooke *et al*. (2000) have demonstrated that the fatty acid profiles of the sows diet during late pregnancy and lactation is an important factor influencing piglet performance. The benefits of dietary manipulations aimed at improving piglet survival, however, remain controversial. The aim of this study was to examine the effect of supplementing the maternal diet with palm and/or soya oil during late gestation on piglet growth performance.

Materials and methods Forty-four multiparous sows of known reproductive history were selected from commercial genetic lines and randomly allocated to one of five dietary treatments groups. From day 85 of gestation sows were offered either: (i) the standard diet (C: 3kg of Pigbreed Pioneer Pellets, BOCM: 12.4 MJ/kg, 3% fat) or the standard diet plus 30% extra energy derived from either (ii) excess pellets (E); (iii) palm oil (PO); (iv) soya oil (SO); or (v) 50:50 mixture of PO:SO (M). Diets (ii)-(v) were isocaloric. All sows were allowed to farrow naturally at term and piglets were sow-reared. Litter sizes were adjusted at birth by cross fostering to equalise the number of piglets reared by the sow. During lactation all sows were offered up to 6 kg of the standard lactation diet (Pigbreed Ultimate Pellets, BOCM: 13.6 MJ/kg, 6% fat). Piglet body weight, crown-to-rump length (CRL) and an estimate of fat-free mass (FFM) using a TOBEC analysing system (Bellinger and Williams, 1993) were recorded at 0, 7, 14 and 21 days of neonatal life. FFM was estimated using the following equation: √(TOBEC reading *CRL) Statistical differences between dietary treatments were assessed using a General Linear Model, ANOVA.

Results Number of live piglets at birth and number of piglets reared were similar between groups. Supplementing the maternal diet had a significant ($P<0.05$) influence on both birth weight and FFM (Table 1). Piglets in the E group were heavier ($P<0.05$) at birth and on day 21 of life compared to the C group as well as having a superior ($P<0.05$) growth rate and a greater ($P<0.05$) FFM than all the other groups. In contrast, the addition of fat to the maternal diet reduced ($P<0.05$) FFM at birth when compared to both the C and E treatments. Interestingly FFM was higher ($P<0.05$) in PO and SO piglets on day 21 of life but remained lower ($P<0.05$) in the M group.

Table 1 Effect of maternal nutrition on body weight, FFM and growth rate during neonatal life

	C (n=9)	E (n=8)	PO (n=9)	SO (n=9)	M (n=9)
Birth weight (kg)	1.60±0.04 ^{a}	1.79±0.05 ^{a}	1.68±0.04	1.65±0.04	1.73±0.04
Body weight d21 (kg)	6.90±0.18 ^{a}	7.68±0.20 ^{ab}	6.71±0.16^{b}	7.11±0.16	7.02±0.17
Growth rate (g/d)	267±8 ^{a}	302±9 ^{abcd}	256±7^{b}	267±7 ^{c}	263±8^{d}
FFM d0 (arb. Units)	148±4 ^{a}	162±5 ^{abcd}	140±4 ^{b}	139±3 ^{c}	141±3 ^{d}
FFM d21 (arb. Units)	412±5 ^{abc}	420±7^{def}	463±5 ^{adf}	442±5 ^{beh}	396±5 ^{cfgh}

Values are presented as least-square means ±SEM, Mean values within each row with a common superscript letter differ significantly: $^{a, b, c, d, e, f, g, h}$ $P<0.05$.

Conclusions Maternal dietary supplementation during late pregnancy influenced the growth and development of the neonatal pig. It is speculated that the addition of fats to the maternal diet increased the body fat reserves of the newborn piglets, thus improving their chances of survival in the immediate post-partum period. Surprisingly, lean tissue growth was promoted in the PO and SO groups over the neonatal period; this effect may improve the efficiency and quality of meat production. Further research is required to increase our understanding of the underlying physiological mechanisms mediating this response.

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Performance and economy of production of growing pigs on two levels of cassava flour waste supplemented with palm kernel cake as replacement for maize

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Introduction Swine production in Nigeria is still at a very low level, though it has been gaining some attention, especially in the South western Nigeria. Being monogastric in nature, the cost of feed in a pig enterprise is enormous and could be as high as up to 75-80% in the fattening herd and 60-65% in the breeding herd. However, to reduce this high cost of dietary ingredients and feeding that are associated with intensive animal production system, more attention should be paid to unused resources which are regarded as useless for human consumption or nutrition and non competitive (Ter Meulen and El-Harith, 1985). Both cassava flour wastes and palm kernel cake fall into this class (Tegbe *et al*, 1995). The aim of this study therefore, was to replace the maize fraction in the diet of the growing pigs with two levels of cassava flour waste (CFW) supplemented with palm kernel cake (PKC).

Materials and methods The utilization of two levels of cassava flour waste supplemented with palm kernel cake in the diets of growing pigs was investigated using thirty six Large White x Landrace growing pigs with average initial live weight of 16.14 ± 0.67kg in a 42-day feeding trial. The pigs were allotted into three treatment groups of four replicates of three animals per treatment group in a Complete Randomized Block Design. They were fed equal quantities of diets containing 10% CFW + 20% PKC and 20% CFW + 20% PKC in place of 40% maize contained in the control diet. This was increased uniformly across the groups during the period of the experiment and they were allowed free access to water in concrete floored pens. The performance and economy of production parameters were monitored throughout the trial.

Results and Discussion In agreement with the findings of Tegbe *et al*. (1995), the body weight gain, protein efficiency ratio (PER) and feed to gain ratio were not significantly ($P>0.05$) affected by the inclusion of the graded levels of CFW+PKC. The costs of feed consumed per day by pigs and their feed conversion in terms of cost of feed / kg live weight of pigs followed the same trend. The two levels of CFW+PKC resulted in comparable economic gains, but superior ($P<0.05$) when compared to the maize-based control diet. Therefore, the diets containing the CFW + PKC could be said to be more cost effective in terms of the cost of feed required for a kilogramme live weight gain ($P<0.05$) than the maize-control diet. Reducing feed cost was not only to obtain cheaper feed, but was also dependent on the production result obtained with the cheaper feed (Phillips, 1984). Hence, the efficiency with which the feed was utilized was of major importance, as observed in this study.

Table 1: Performance and costs of feed conversion of growing pigs fed CFW supplemented with PKC

Parameters	Control diet	10%CFW +20%PKC diet	20%CFW +20%PKC diet	SEM
Av. Daily Weight Gain (kg)	0.33	0.39	0.38	0.03
Feed: Gain	3.99	3.64	3.47	0.23
PER	1.48	1.68	1.57	0.10
Feed cost/Day (N)	16.53[a]	12.27[b]	11.08[b]	0.51
Feed cost/kg Weight Gain (N)	56.09[a]	38.33[b]	32.85[b]	3.10

$1.00 = N150.00 (N = Nigerian Naira).

Conclusion It could therefore be inferred from the results of this study that cassava flour waste (CFW) supplemented with palm kernel cake (PKC) in diets of growing pigs can be efficiently used for the total replacement of the maize fraction without depressing the performance of the animals in an attempt to reduce the cost of feeding.

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Cow serum and colostrum immunoglobulin (IgG1) concentration of five suckler cow breed types and subsequent immune status of their calves

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Introduction Adequate disease resistance in the immediate post parturient period is essential for the health and survival of a calf. Immunoglobulins (Igs) are proteins produced in response to stimulation by antigens (foreign substances) that subsequently inactivate or destroy these antigens. The sera of neonatal calves is essentially devoid of Ig or agammaglobulinaemic (Stromont, 1972). Thus they are entirely dependent on the Igs received through the ingestion of colostrum to provide passive immunity. IgG1 is the most abundant Ig present in colostrum. The IgG1 concentration of the colostrum, in addition to colostrum intake, influences the immune status of the calf. McGee (1997) has identified breed effects for serum and colostrum Ig status in suckler cows and consequently serum Ig status of their progeny. The objective of this study was to determine the effect of cow breed type on (a) cow serum and colostrum IgG1 concentration and (b) subsequent calf serum IgG1 concentration and zinc sulphate turbidity (Z.S.T.) units.

Materials and methods The Grange spring calving suckler herd, was used in this study. This herd was comprised of 1st, 2nd and 3rd parity cows. Five cow breed types were examined: LF (Limousin x Friesian), LLF (Limousin x Limousin x Friesian), L (Limousin), C (Charolais) and SLF (Simmental x Limousin x Friesian). The cows were blood sampled by jugular venipuncture at 90 (75 +), 60 (74-45) and 30 (44-15) days pre partum. They were also blood sampled at parturition and 30 (15+) days post partum. Immediately post partum and prior to suckling a 20 ml sample of colostrum was obtained. The IgG1 concentration of the blood and colostrum were determined. A blood sample was obtained from the calves 48 (40-56) hours post partum. This sample was also analysed for IgG1 concentration along with Z.S.T. units. The data were subjected to analysis of variance using SAS. ***Parity was used as a covariate - Deleted***

Results There was no significant difference in cow serum IgG1 concentration between the breed types, 90 days or 30 days pre partum (Table1). At parturition cow serum IgG1 concentration was significantly lower for LF cows than for all other breed types. Serum IgG1 concentration for L cows at parturition was significantly higher than that of all other cow genotypes except C. Values for LLF, SLF and C cows were intermediate and not significantly different from one another. This suggests a greater transfer of IgG1 from serum into mammary secretion which is associated with increased colostral Ig mass production in dairy cross cows relative to beef cows. These results agree with the findings of McGee (1997). However the decrease in cow serum IgG1 concentration between 90 days pre partum and parturition was not significantly different. Thirty days post partum there was no significant difference between the breed types in IgG1 concentration. There was no significant effect of breed type on colostrum IgG1 concentration. Progeny serum IgG1 concentrations 48 hours after birth were not significantly different. However calf serum Z.S.T. units were significantly lower for progeny of C cows than that of all other breed types, except LLF. There were no other significant differences between the genotypes. Milk yield, which should reflect colostrum yield, was greater for dairy cross genotypes than that of beef breed types. The progeny of the higher yielding animals would be expected to have greater Ig intake as a result of this higher colostrum yield. This should be reflected in a higher serum Ig status.

Table 1 Cow serum IgG1 concentrations, colostrum IgG1 concentration, calf serum IgG1 concentration and Z.S.T. units

	LF(n)	LLF (n)	L(n)	C(n)	SLF(n)	s.e.		Sig.[1]
Cow serum IgG1(mg/ml)						n_{max}	n_{min}	
90 days pre partum (a)	11.7 (16)	10.8 (17)	11.6 (15)	12.8 (11)	10.5 (13)	0.94	1.18	NS
30 days pre partum	9.6 (16)	7.4 (13)	10.1 (7)	10.4 (14)	9.1 (17)	0.72	1.20	NS
Parturition (b)	5.5 ^{c} (22)	7.9 ^{b} (21)	9.5 ^{a} (15)	8.4 ^{ab} (16)	7.3 ^{b} (23)	0.42	0.56	***
Decrease (a) to (b)	-6.3 (16)	-3.5 (15)	-3.6 (13)	-3.5 (10)	-3.4 (12)	1.02	1.16	NS
30 days post parum	11.2 (22)	11.8 (19)	11.6 (15)	12.2 (17)	11.8 (22)	0.62	0.82	NS
Colostrum IgG1 (mg/ml)	66.3 (18)	66.9 (17)	70.3 (8)	77.8 (15)	75.3 (18)	5.49	8.58	NS
Calf serum at 48 hours								
IgG1 (mg/ml)	25.1 (20)	24.4 (16)	23.0 (13)	18.6 (14)	25.2 (20)	2.02	2.66	NS
Z.S.T. units	18.8 ^{a} (20)	15.6 ^{ab} (17)	16.6 ^{a} (13)	13.0 ^{b} (14)	16.1 ^{a} (20)	1.23	1.62	*
Milk yield (kg/day)	9.0 ^{a} (18)	6.8 ^{bc} (17)	4.8 ^{c} (15)	5.3 ^{c} (15)	7.6 ^{ab} (21)	0.47	0.60	***

[1] * = P<0.05 ** = P<0.01 *** = P<0.001

Conclusions There was no significant effect of cow breed type on serum IgG1 concentrations 90 days pre partum but the concentration was significantly lower for LF cows than for any other breed at parturition. There was no significant effect of cow breed type on colostrum IgG1 concentration. Calf serum Ig levels were lowest for the progeny of C cows as indicated **by** Z.S.T. units. and IgG1 concentration. Cow breed type influenced calf immune status **in this study population**.

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Reproductive performance of Holstein dairy cows kept in two conditions in Central Java, Indonesia

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Introduction Milk production in the tropics will typically follow one of two general strategies : either the use of crossbreeding using exotic cattle on the indigenous cattle or the maintenance of purebred *Bos taurus* dairy breeds. The current work investigates the use of the Holstein as a producer of fresh milk and replacement stock (RS) in Indonesia. In an attempt to ensure a sustainable system which maintains RS, one dairy breeding station (BS) was operated with intensive management in a favourable elevated location in Banyumas district, Central Java. A number of smallholder dairy farmers (SF) were established on the surrounding lower area to provide RS at the village level. On both BS and SF AI was the sole mating method using semen from imported Holstein bulls. Maintaining optimal reproductive efficiency is required to achieve proper dairying profitability as inefficient reproduction not only reduces milk yield and the available RS, but also increases culling due to reproductive failure, breeding cost and veterinary fees (Esslemont *et al*., 2001). The aim of this research is to evaluate the various indices of reproductive performance in Holsteins in the two locations.

Materials and methods Data were collected for milk yield and reproductive records of Holstein cows and heifers ,180 animals in BS and for 359 animals in SF between 1991 to 2001. The complete lactations of milk yield calculated from weekly (for BS) and monthly (for SF) records were around 3924 ± 1089 kg in BS and 3060 ± 1154 kg in SF. The reproductive data included birth date, calving date, service date, conception date, and number of services allowing a number of reproductive indices to be derived (Table 1). Incomplete records and data with obvious recording errors were identified as outliers on scattered box-plot transformation and omitted from future analysis. Analyses were conducted for the effect of location on the various reproductive variables by one way ANOVA and Tukey's test was used to test for the mean difference of the reproductive indices.

Results The majority of the parameters of reproductive performance of the Holstein cows investigated at the two locations showed statistically significant differences ($P<0.01$) the exception being gestation length. Age at first calving was significantly higher for cows in BS than in SF (33 vs 29 months), but most of reproductive indices in BS were shorter compared to those in SF. The shorter periods both for the first mating interval and the first mating to conception interval in BS contributed to a shorter period of days open. Days open at both locations showed a high mean with wide ranges indicating moderate to severe problems of anestrous and temporary infertility as indicated by low conception rates at first mating (28%) and high incidence of reproductive disorders (19%). These indices resulted in both locations having calving intervals higher than those generally recommended.

Table 1 Reproductive performance of Holstein dairy cows

Reproductive Indices	Breeding Station				Smallholder Farmers				Statis.
	N	Range	Average	Sd	N	Range	Average	Sd	Differ
Age at 1st calving (months)	214	19 – 49	33	7	171	23 - 41	29	3	P<0.01
Calving - 1st mating (days)	549	16 – 233	92	45	515	25 - 238	109	5	P<0.01
1st mating - conception (days)	543	0 – 295	52	67	571	0 - 310	57	70	P<0.05
Days open (days)	549	24 – 453	149	86	571	24 - 450	159	97	P<0.01
Gestation length (days)	308	260 – 290	273	6	382	262 - 291	276	5	P>0.05
Calving interval (days)	483	271 – 646	418	77	497	260 - 648	433	84	P<0.05
Cows served < 60 days	549	-	159 (0.29)	-	514	-	83 (0.16)	-	-
Concep. rate at 1st mating+	421	-	116 (0.28)	-	-	-	-	-	-
Conception rate +	421	-	268 (0.64)	-	-	-	-	-	-
Calving rate+	421	-	242 (0.57)	-	-	-	-	-	-
Reproductive disorder +	421	-	80 (0.19)	-	-	-	-	-	-
Services per conception	564	1 - 6	2.0 ± 1.2	1.2	605	1 - 6	2.0 ± 1.2	1.2	-

+ Observation during the year of 2001 with the number in the bracket indicating the proportion of successful cow and heifer to the breedable population the exception for reproductive disorder indice.

Conclusions It is interesting to note that in both locations the animals' reproductive performance was below target. For most parameters the reproductive performance was significantly inferior on the SF than the BS which was probably due to a combination of less favourable climatic conditions and inferior general and nutritional management. Thus continued attention towards the management is required if sustainable systems of producing purebred RS are to be achieved for Holstein dairy cows in Indonesia.

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The effect of diet on the expression of oestrous behaviour with high genetic merit Holstein Friesian dairy cows

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Introduction Poor reproductive performance is a major problem on dairy farms throughout the United Kingdom, resulting in reduced financial returns for the farmer. As the genetic merit of the cow increases, an increasing proportion of nutrients are partitioned towards milk production and this can result in the cow entering into a more severe negative energy balance (NEB). Previous studies have shown that the extent of NEB may influence the expression of oestrous behaviour (Orihuela, 2000). The aim of the current study was to examine the effect of offering a high or low proportion of concentrate (70% and 40% respectively, with the balance being grass silage) in the total diet, on the expression of oestrous behaviour of high genetic merit Holstein Friesian lactating dairy cows, using optical electronic oestrous detection equipment.

Materials and methods 50 early lactation Holstein-Friesian dairy cows (lactation number 1 to 4) were allocated to two diets in a randomised block design, with cows randomised across treatments at calving. The cows were blocked on parity, genetic merit (PIN value), live weight at calving, condition score at calving and milk yield on days 7, 8 and 9 of lactation, as recorded during a 10 day build up period before being allocated to treatment. The build up diet consisted of concentrate and grass silage in the ratio of 30:70 (DM basis). Following allocation to their diets, cows were offered a total mixed ration consisting of either 70% concentrate and 30% grass silage (high) or 40% concentrate and 60% grass silage (low) along with minerals and vitamins. Complete diet intake was measured for each group of cows. The number of primary and secondary mounts were measured using optical electronic oestrous detection equipment. A primary mount was defined when the cow was mounted by another animal and a secondary mount when the cow mounted another animal. Data were analysed by ANOVA, where differences between treatment means were examined.

Results There was no significant effect of diet on milk fat content but cows on the high concentrate diet had significantly higher milk yields and milk protein contents than those on the low concentrate diet. There was no significant effect of diet on number of mounts or on the duration of mounting activity for cows in heat 1 and heat 2, defined as the primary and secondary heats post-calving based on twice weekly progesterone analysis of milk samples (Table 2). The number of primary mounts in heat one were 8.2 and 1 for the high and low groups respectively, where there was only one occurrence of a primary mount for one cow offered the low diet.

Table 1 Intake of feed and production data for cows offered high and low diets

		HIGH (70:30)	LOW (40:60)	SED	SIG
Intake	Total DMI (kg/day)	19.00	14.82	0.596	***
	Silage DMI (kg/day)	5.72	9.17	0.170	***
	Concentrate DMI (kg/day)	13.28	5.64	0.459	***
Production	Milk yield (kg/day)	30.83	24.16	1.503	***
	Milk Fat (g/kg)	39.27	41.12	1.102	NS
	Milk Protein (g/kg)	32.81	30.70	0.501	***

Table 2 Oestrous behaviour of cows offered high and low diets

HEAT	MOUNT TYPE		HIGH (70:30)	LOW (40:60)	SED	SIG
1	*Primary*	*No. observations (n)*	4	1		
		No. mounts	8.2	1.0	11.38	NS
		Duration of mount (sec)	7.6	2.0	6.78	NS
		Total duration of mounting activity (min)	177.3	0.03	256.47	NS
1	*Secondary*	*No. observations (n)*	6	10		
		No. mounts	6.0	4.4	3.18	NS
		Duration of mount (sec)	4.3	7.3	2.29	NS
		Total duration of mounting activity (min)	517.1	160.1	184.28	NS
2	*Primary*	*No. observations (n)*	7	12		
		No. mounts	2.1	3.8	1.36	NS
		Duration of mount (seconds)	6.5	5.6	1.97	NS
		Total duration of mounting activity (min)	96.6	165.3	86.43	NS
2	*Secondary*	*No. observations (n)*	11	13		
		No. mounts	3.2	5.0	2.03	NS
		Duration of mount (sec)	3.4	3.8	0.84	NS
		Total duration of mounting activity (min)	265.1	230.8	100.19	NS

Conclusions Offering a low concentrate diet did not have any negative impact on the oestrous activity in this study.

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Estimating daily yield from am-pm milk recording schemes for Holstein-Friesian cows in the United Kingdom (UK)

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Introduction Pressure to reduce farm costs in milk production has seen an increasing demand on Milk Recording Organisations (MROs) to provide alternatives to the standard supervised recording scheme based on testing two milkings within a 24 hour period at 4-weekly intervals. With alternative schemes, a balance has to be sought between cost reduction and maintaining accuracy so that herd management decisions and genetic evaluations are not compromised. An am-pm recording scheme has been introduced by MROs as a way of reducing cost. It is based on testing one milking at 4-weekly intervals with the monthly test alternating between the morning and the evening milking. There is a need to establish how accurate this scheme is in estimating daily yield and to determine the weights required so that this information can be suitably included in the national genetic evaluation system.

Materials and Methods After edits on milking times, milking intervals, number of daily milkings, days in milk, test day milk yield and breed code, data (DATA1) comprised of 1,026,015 Holstein-Friesian cow records. Each test was carried out at approximately 4-weekly intervals and consisted of a morning (AM) and an evening (PM) record taken within a 24-hour period to give a total daily test-day milk yield (DMY). Animals were grouped into 3 parity classes (P); lactation 1, 2-5 and ≥ 6. Stages of lactation ranged from 5 to 305 days (DIM) or 1 to 11 months (S). The AM milking interval (MI) was calculated as time from the beginning of the previous PM milking to the beginning of the AM milking. For PM, MI was calculated as 1440 minutes minus the AM MI. Both AM MI and PM MI were grouped into 7 classes of 30-minute intervals (MIC). To determine the most important sources of variation affecting milk yield ratios, analyses of variance were carried out on DMY:AM MILK and DMY:PM MILK. The effects included in the model were MIC, P and S. Using DMY as the dependent variable, Model I fitted a separate regression for each MIC with an additional regression coefficient on DIM (DeLorenzo and Wiggans, 1986). Model II fitted a separate regression for every combination of MIC, S and P (Liu *et al*., 1999). A sub-set of DATA1 was selected to include cows with 10 consecutive tests only and comprised of 579,420 records (DATA2). Factors (regression formulae) from both models and those currently used by NMR, the major UK MRO, were applied to DATA2 to compare means and standard deviations (sds) of differences between observed and estimated DMY. Current NMR factors were from the study of DeLorenzo and Wiggans (1986) using USA milk records. Analyses were carried out using SAS Version 8.2.

Results Significant sources of variation affecting yield ratios were MIC, S and P ($P<0.001$). P was the least important source of variation and further analyses showed that there were significant differences in yield ratios between parity class 1 and both classes 2 and 3 ($P<0.001$) but not between parity classes 2 and 3. From Table 1, estimation of DMY from AM milkings were of higher accuracy than estimates using PM milkings as shown by the smaller mean square errors, higher correlations and estimated sds closer to the observed sds. Estimates using Model II gave an improved fit to DATA1 over Model I. When factors were applied to DATA2, Models I and II showed zero mean differences and also smaller sds of the difference compared with NMR factors, particularly for PM data (Table 2).

Table 1. Correlations between observed and estimated DMY ($r_{yt,\hat{y}t}$), mean square errors (mse) and standard deviations ($\sigma_{\hat{y}t}$) of DMY estimates from single milkings

	AM			PM		
Model	$r_{yt,\hat{y}t}$	$\sigma_{\hat{y}t}$	√mse	$r_{yt,\hat{y}t}$	$\sigma_{\hat{y}t}$	√mse
I	96.2	7.56	2.15	94.5	7.42	2.57
II	96.2	7.57	2.14	94.6	7.44	2.54

Conclusions The best fitting model was II which included MIC, S and P. Factors obtained from this analysis are now being applied by NMR to estimate daily yield in am-pm schemes, replacing those based on USA data. To account for the accuracy of DMY estimated from am-pm records, appropriate weights for lactation yield have been derived from R^2 values so that these records can be incorporated into the national genetic evaluation system.

Table 2. Comparison between observed and estimated DMY using UK and NMR factors

Factors		**Mean difference**	**s.d. of difference**	**Range of differences**	
				Minimum	**Maximum**
I	AM	-0.02	2.05	-19.32	18.20
	PM	0.01	2.47	-23.18	21.15
II	AM	-0.01	2.04	-19.92	17.99
	PM	0.04	2.43	-23.36	21.46
NMR	AM	0.20	2.10	-18.94	19.47
	PM	-0.30	2.86	-28.79	25.98

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Relationship between dietary intake and yield in milk of C:16 - C:20 fatty acids in dairy cows given complete diets based on grass silage and malt distillers grains (Draff)

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Introduction Previous work has reported an increase in the unsaturated fatty acid composition of cows milk when diets containing malt distillers grains (Draff) are fed (Hyslop and Roberts, 1988). However, the underlying nature and efficiency of the transfer of dietary fatty acids (FA) to milk fat remains to be examined. The objective of this study is to quantify the relationships between intake of C:16 - C:20 dietary FA and their output in milk.

Materials and methods Fifteen multiparous Holstein/Friesian cows in early lactation were used in a cyclic changeover design experiment consisting of 4 three-week periods. Cows were given *ad libitum* access to one of five complete diets based on grass silage (DOMD: 690 g/kg) where Draff plus additional minerals replaced barley and soyabean meal at increasing rates. Draff/minerals inclusion rates were 0 (Diet 0), 93 (Diet 1), 184 (Diet 2), 277 (Diet 3) and 368 (Diet 4) g/kg DM whilst silage inclusion rate was almost constant at 408-411 g/kg DM across the diets. Cows were individually fed through Calan-Broadbent gates where feed intake, milk yield and milk composition was determined during the last four days of each three-week period. Additional milk samples for fatty acid composition were also taken. Dietary intake of C:16 - C:20 and their corresponding output in milk were calculated and analysed by analysis of variance. Relationships between dietary FA intakes and outputs in milk across the diets were also analysed by regression analysis.

Results Production parameters have been reported previously. Only the intakes (I), yields (Y) and efficiencies (E) of FA transfer to milk are reported here (Table 1). Generally, both the I and Y of FA increased as Draff/minerals replaced barley/soyabean meal in the diets reflecting the high fat content of Draff (107 g/kg DM). Efficiencies > 1 were seen for C:16.0, C:16.1, C:18.0 and C:18.1 reflecting either de-novo synthesis, ruminal bio-hydrogenation or desaturation. Except for C:18.3 and C:20, the E of FA transfer to milk declined significantly (at least $P<0.05$) for all individual FA, the C:16 - C:20 FA in total ($P<0.01$) and the C:18 acids taken together ($P<0.05$). The quadratic relationship between I and Y of total C:18 FA for individual cows across diets 0-4 is depicted in Figure 1.

Table 1. Dietary intakes (I), yields in milk (Y) and efficiencies (E) of C:16 - C:20 fatty acid transfer to milk

		Diet						
Fatty acid		0	1	2	3	4	sed	Sig
C:16.0	I	114^{a}	149^{b}	186^{c}	213^{d}	217^{d}	4.94	***
	Y	262	268	278	259	244	14.10	
	E	2.29^{a}	1.83^{b}	1.15^{c}	1.21^{d}	1.10^{d}	0.101	**
C:16.1	I	10^{a}	11^{b}	14^{c}	16^{d}	16^{d}	0.40	***
	Y	23	23	22	21	23	1.37	
	E	2.39^{a}	1.96^{b}	1.55^{c}	1.28^{d}	1.41^{cd}	0.130	*
C:18.0	I	10^{a}	13^{b}	15^{c}	17^{d}	18^{d}	0.41	***
	Y	82^{a}	99^{b}	113^{c}	111^{bc}	108^{bc}	6.36	*
	E	7.87^{a}	7.85^{a}	7.39^{a}	6.40^{b}	6.13^{b}	0.442	*
C:18.1	I	69^{a}	101^{b}	134^{c}	159^{d}	170^{e}	3.64	**
	Y	171^{a}	193^{b}	219^{c}	233^{cd}	242^{d}	10.32	*
	E	2.47^{a}	1.96^{b}	1.67^{c}	1.46^{d}	1.39^{d}	0.101	*
C:18.2	I	178^{a}	249^{b}	324^{c}	382^{d}	400^{d}	8.67	***
	Y	24^{a}	27^{b}	29^{b}	27^{b}	29^{b}	1.33	*
	E	0.13^{a}	0.11^{b}	0.09^{c}	0.07^{d}	0.06^{d}	0.001	**
C:18.3	I	160^{a}	163^{a}	179^{b}	179^{b}	166^{a}	4.74	*
	Y	7	5	7	10	6	5.54	
	E	0.04	0.03	0.04	0.05	0.03	0.010	.
C:20.0	I	2	2	2	2	2	0.06	
	Y	2	2	2	2	2	0.38	
	E	1	1	1	1	1	0.19	.

		Diet						
Fatty acid		0	1	2	3	4	sed	Sig
C:16.0	I	542^{a}	688^{b}	885^{c}	970^{d}	988^{d}	22.41	***
-C:20.0	Y	568^{a}	615^{ab}	668^{b}	664^{b}	657^{b}	26.42	**
acids	E	1.05^{a}	0.91^{b}	0.79^{c}	0.68^{d}	0.65^{d}	0.041	**
Total	I	416^{a}	526^{b}	652^{c}	739^{d}	753^{d}	17.05	***
C:18	Y	284^{a}	324^{b}	369^{c}	382^{c}	382^{c}	16.85	*
acids	E	0.68^{a}	0.62^{b}	0.57^{c}	0.52^{d}	0.50^{d}	0.024	*

Values not sharing common superscripts differ significantly.

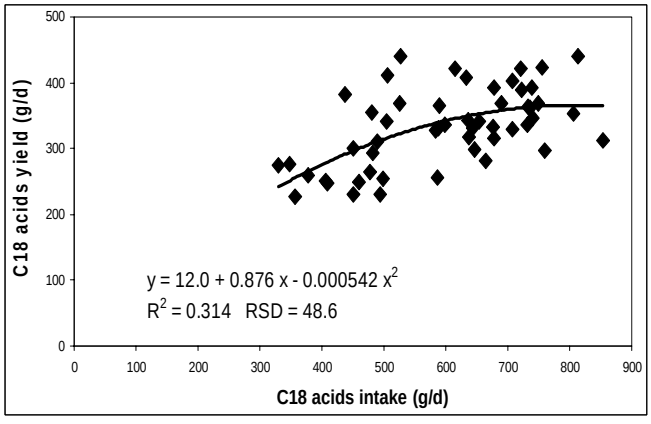

Figure 1. Quadratic relationship between dietary intake and yield in milk of total C:18 fatty acids

Conclusions The underlying biological relationship between dietary fatty acid input and corresponding fatty acid output in milk is quadratic in nature with efficiencies of transfer declining as dietary fatty acid intake increases.

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Site and extent of starch degradation in the dairy cow. A comparison between *in vitro, in situ* and *in vivo* measurements

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Introduction Starch digestion in the rumen and large intestine yields volatile fatty acids that are either ketogenic (acetate, butyrate) or glycogenic (propionate) precursors, whereas starch digestion in the small intestine yields mainly glycogenic precursors. Therefore, supply of ketogenic and glycogenic precursors from starch is related to the site of digestion. In this study the site of digestion of starch from wheat, maize and potato was estimated by *in vitro* methods, i.e. the gas production technique and an enzymatic technique, and the nylon bag technique. The *in vitro* and *in situ* results were validated by *in vivo* experiments with dairy cows, determining the site and extent of starch degradation.

Materials and methods The gas production technique (Cone *et al*., 1996) was used to simulate fermentation in the rumen. Digestion in the small intestine was simulated by incubation in a pancreatic solution (Cone, 1991). Samples were incubated in nylon bags in the rumen for 3, 6, 12, 24, 48 and 336 h in triplicate in each of 3 cows. In a Latin square design experiment, four dairy cows fitted with a rumen cannula and T-piece cannulæ in the duodenum and ileum, were fed either a starch-free diet (43 % grass silage, 27 % ensiled sugar beet pulp, 30 % concentrate mixture with 70 % dried sugar beet pulp) or diets in which the concentrate ingredient sugar beet pulp had been substituted with either wheat meal, maize meal or potato starch. Diets were fed for a period of four weeks, with faecal collection taking place in the third week and digesta collections in the fourth week. Intestinal fluxes were measured with the dual-marker technique, using Cr-NDF and Co-EDTA. Starch was analysed enzymatically. Differences between treatments were tested with a Student's t-test.

Table 1 Starch content and *in vitro* and *in situ* degradation parameters of different starch sources

	Wheat	Maize	Potato
Starch content (g/kg DM)			
	686[a]	590[b]	997[c]
Gas production technique (ml/g OM)			
5 h	81[a]	49[b]	14[c]
10 h	277[a]	209[b]	144[c]
20 h	315[a]	314[a]	364[b]
Pancreatin (g/kg starch degraded)			
2 h	249[a]	423[b]	79[c]
4 h	472[a]	613[b]	107[c]
Nylon bag technique			
a (g/kg starch)	430[a]	66[b]	400[a]
b (g/kg starch)	569[a]	925[b]	592[a]
c (h^{-1})	0.317[a]	0.062[b]	0.063[b]
Rumen bypass starch (g/kg)	135[a]	471[b]	337[c]

[a,b,c]Results with different superscript are significantly different at $P < 0.05$ (Student's t-test)

Results Differences were observed in gas production among starch sources at 5 and 10 h incubation. After 20 h incubation all samples showed high gas production (Table 1), with approx. 90% of starch from all sources being degraded. Digestion with pancreatin was low for potato starch. Maize starch displayed a lower a-fraction and a higher b-fraction in comparison to wheat and potato. Wheat starch had the highest degradation rate (c). Wheat had lowest rumen bypass starch and maize highest. For potato starch a lag period of 10.6 h was observed before degradation in the nylon bags started. The *in vivo* experiments showed that the rumen was the main site of digestion (Table 2). Potato starch, showing low initial gas production and a long lag time with the nylon bag technique, was fermented for 84 % in the rumen and not digested in the small intestine, which agreed with the digestibility in pancreatic juice. Almost all starch entering the large intestine was digested.

Table 2 Effect of starch sources on the site of starch digestion in dairy cows.

Parameter	Treatment			SED
	Wheat	Maize	Potato	
Starch Intake, kg/d	3.46	3.90	3.69	0.11
Rumen, g/kg starch intake	897[a]	753[b]	840[a]	25
Small intestine, g/kg of duodenal flux	698[a]	652[a]	0[b]	59
Large intestine, g/kg of ileal flux	720[b]	716[b]	857[a]	47

SED: standard error of difference
[a,b,c]Results with different superscript are significantly different at $P < 0.05$ (Student's t-test)

Conclusions Potato starch displayed low rumen digestibility during the first 10 hrs *in vitro* and *in situ*. However, final *in vitro, in situ* and *in vivo* rumen digestibility of potato starch was high. The low initial rate of digestion might be compensated by a low ruminal passage rate of potato starch or rumen fluid used in vitro and in situ was not adapted to potato degradation opposite the in vivo experiments. Incubation in pancreatin indicated low *in vivo* digestibility of potato starch in the small intestine, but for the 3 samples no relationship between *in vitro* and *in vivo* was found in ranking of starch sources according to digestibility in the small intestine.

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Effects of feeding fish meal or fish oil fatty acids on energy balance and plasma concentrations of insulin and insulin-like growth factor binding proteins in early postpartum dairy cows

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Introduction The early lactation period in dairy cattle is characterized by negative energy balance (NEB). Insulin-like growth factors (IGFs) have an important role in regulating nutrient utilization and act as a mediator of the effects of energy balance on reproduction. The capacity of IGF-I to access cell surface receptors is controlled by insulin-like growth factor binding proteins (IGFBPs). Insulin is a key signal of metabolic status and its infusion altered IGF-I and IGFBP concentrations in plasma (Butler et al., 2003). The objective of the present study was to compare the effect of dietary supplementation of fish meal (FM) or Ca salts of fish oil fatty acids (CaFOFA) on energy balance during early lactation period and on the circulating concentrations of insulin and IGFBPs on d 32 post-partum (PP).

Materials and methods From d 5-50 PP, cows (n=30; 6/treatment) were fed with any of five isonitrogenous, isoenergetic and isolipoid diets. The diets contained palm oil fatty acids (Control), 1.25, 2.5 or 5% menhaden fish meal (Sea-Lac, Omega Protein, Hammond, LA, USA) or 2.3% CaFOFA (EnerGII Repro; Bioproducts Inc., Fairlawn, OH, USA). Rations were calculated to provide similar amounts of metabolizable protein and NE_L using the Cornell Net Carbohydrate and Protein System (Fox et al., 1992). Energy balance (EB) was calculated as suggested by NRC (NRC, 2001). Plasma insulin concentrations were determined by a radioimmunoassay technique using antibodies from the Linco insulin RIA kit (Linco Research Inc., St. Louis, MO, USA) and bovine insulin (Elanco Animal Health, Greenfield, IN, USA). Plasma samples were collected at d 32 PP from four cows on each of the diets 1, 3, 4 and 5, and three cows on diet 2, and subjected to Western ligand blotting. Plasma proteins were denatured in loading buffer (13·3% SDS, 0·42 M Tris, 0·013% bromophenol blue, pH 6·5) at 100 ºC for 3 min and separated using discontinuous SDS-PAGE at 175 V (double gel unit; Life Technologies Inc., Gaithersburg, MD, USA). Proteins were transferred to a nitrocellulose membrane overnight at 10 V using a plate electrode apparatus (BioRad Laboratories Inc., Hercules, CA, USA). Membranes were incubated for 16 h with ^{125}I-IGF-I, washed, and placed on a phosphoimager screen for 48 h. Band intensities were quantified using a Bio-Imaging Analyzer BAS 1000 (Fuji Photo Film Co. Ltd, Tokyo, Japan). Abundance of the IGFBPs is expressed in arbitrary units. The EB data were analyzed using the Proc Mixed for a completely randomized design with repeated measures, and the insulin and IGFBP data were analyzed using the GLM procedure (SAS, 2001).

Results Days to positive energy balance were similar between the diets (P=0.82, Figure 1). The time effect was highly significant (P<0.001) but the interaction between time and diet was not significant (P=0.71). Plasma concentration of insulin was not affected by the diet (P=0.70) but the lsmean of plasma insulin concentration of cows on the control diet was smaller than for other diets (0.21±0.16, 0.30±0.17, 0.30±0.17, 0.31±0.16 and 0.33±0.12 ng/ml, respectively). Plasma IGFBP-3 (40-44 kDa), IGFBP-2 (34 kDa), IGFBP-5 (30 kDa), a 29 kDa IGFBP, a 26 kDa IGFBP, and IGFBP-4 (22 kDa) concentrations were not affected (P=0.08) by the diets.

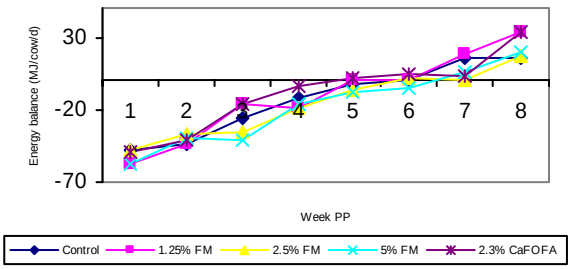

Figure 1. Effect of diet on weekly net energy balance (MJ/cow/d)

Conclusions The results of the present study demonstrated that pattern of energy balance in early lactation cows was similar for different fat supplements used in this experiment. Fish meal, up to 5 % of total ration DM can be used for early lactation cows without any apparent adverse effect on energy balance. Circulating concentrations of insulin and IGFBPs on d 32 PP were similar between the diets.

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The effect of corn silage treated with urea and ammonia on performance of Holstein dairy cows in mid lactation

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Introduction Corn silage is a popular feed for dairy cows in Iran. Corn plant as silage produces the highest amount of digestible nutrients per acre after sugarcane and casava. The well-fermented corn silage contains medium to high content of digestible energy but its level of digestible crude protein is usually low. This is the main reason for application of nitrogenous additives such as urea and ammonia during ensiling. This kind of supplementation also increases air stability of the silage after opening. The ammonia-treated silage gives higher content of digestible energy because of the restriction of fungal growth. It has been shown that urea and ammonia treating corn silage increase dry matter intake and milk yield in dairy cows (Huber and Santana 1973). The aim of this study was to investigate the result of these hypothesises in an intensive dairy production.

Materials and method The corn plant was harvested at a dry matter content of 26% (1/2 to1/3 milk line). Experimental treatments were 1) untreated corn silage, 2) urea treated corn silage (0.725% fresh weight), 3) ammonia treated corn silage (0.4% fresh weight). Nine dairy cows in mid-lactation were arranged in a 3×3 change over design for three periods of 21 days (14 adaptation and 7 sampling) and fed ad-libitum in TMR form, diets containing , 43% roghages (22% corn silage + 21% alfalfa hay) and 57% concentrate. Experimental diets were formulated based on NRC (2001) recommendations. Dry matter, CP, NDF,ADF and Ash content of feeds and feces were measured according to the methods of AOAC(1990). The other measured parameters were nutrients, digestibility, milk yield, milk components, MUN, blood glucose, BUN, rumen pH and ruminal N-NH_3 concentration. The data were analysed using GLM procedure of SAS (6.12).

Results Treating with ammonia or urea significantly increased crude protein contents of silages ($P<0.05$). Dry matter intake (kg) milk fat (%), milk protein (%), lactose (%), SNF (%), TS (%) and MUN were not affected by the experimental treatments. Milk production by the cow were similar in all treatments. Rumen pH was not influenced by treatments. BUN increased significantly ($P<0.05$) in the treated silages compared with the control. No significant differences were detected between treatments in DM and OM digestibilities (Table 1) but, CP digestibility differed significantly ($P<0.05$). NDF digestibilities and N-NH_3 content of taken samples were similar in all treatments.

Table1. Average feed intake, milk yield and apparent nutrients digestibility

Parameters	treatments			s.e.
	1	2	3	
DMI(Kg/day)	21.29	20.85	20.38	0.29
Milk yeild(Kg/d	24.91	24.28	25.01	0.39
Digestibility(%)				
DM	70.53	71.37	70.54	0.86
OM	75.25	73.00	72.15	0.8
CP	73.78^{a}	77.83^{b}	75.62^{ab}	0.9
NDF	61.19	64.93	65.24	1.38
ADF	50.57	50.60	49.64	2.16

^{a,b,}Means in rows within a category with unlike superscripts differ significantly.($p<0.05$).

Conclusion Although, the cow performances in different treatments in this study were similar in most of the measured parameters but it seems in these kind of treatments an approprite source of FME must be provided. The significant content of BUN shows that probably the FME content of the the utilized diets had been lower than the required levels. However, the general performance of the experimental cows in the treated diets were better than control and the air stability of treated silages were excellent. More studies with larger number of cow are recommended in the provincial dairy industry

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Effect of supplemental fat and varying levels of non-structural carbohydrate on performance of Holstein dairy cows

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Introduction Carbohydrate not recovered in NDF is referred to as nonfibre carbohydrate (NFC) and includes starch, sugars, pectins and beta glucans. The optimal level of dietary NFC for lactating cows is not clearly defined. It has been demonstrated that milk production was decreased when dietary NFC was greater than 45 to 50% or less than 25 to 30% of dry matter. However , only small differences in milk production occurred as dietary NFC was varied from 35 to 40% (Batajoo *et al*, 1994). Replacement of NSC with suplemental fat decreases the amount of energy that is available for growth of ruminal microorganisms and may decrease microbial protein synthesis. The quantity of fermentable carbohydrate is the single most important determinant of microbial protein production and may have a great impact on ruminal metabolism and the overall performance of dairy cows (Elliott *et al*, 1995). The objective of this experiment was to determine the effects of supplemental fat in concentrates containing different amount of NFC on performance of dairy cows.

Materials and methods Eight multiparous Holstein cows averaging 46 ± 8 days in milk (DIM) were allotted to a replicated 4*4 latin square design. Each period consisted of 14 days for adjustment to treatments, followed by 7 days for sample collection. Treatments, in a 2*2 factorial arrangement, were: 1) high NFC, no added fat; 2) high NFC, 2.5% added fat; 3) low NFC, no added fat and 4) low NFC, 2.5% added fat. The NFC content was varied (high NFC=40% and low NFC=30% of DM) by the replacement of the barley grain in the high NFC diet with cotton seed hulls (CSH). Diets were formulated to contain 170g/kg DM CP and NE_l=6.90MJ/kg was calculated from NRC (2001). Milk weight was recorded during days 15 to 21 of each period. Milk composition of milk sampled during the last 2 days of each period was determined by milc-0-scan. Ruminal fluid was sampled by stomach tube 2 hours post-feeding on day 21 of each period. Data were analyzed as a replicated 4*4 latin square using the general linear models procedure of SAS.

Results The addition of fat to the low NFC diet increased milk production to amounts equivalent to those observed when cows were fed high NFC diets (table 1). Contents of milk fat, protein and SNF were not significantly different among diets. The DMI and ruminal pH were unaffected by fat or level of NFC, but the concentration of ruminal NH3 was increased when diets contained low NFC.

Table 1 Mean intake, milk production and composition, ruminal pH and NH3 of cows fed diets varying in content of NFC and fat

Trait	Diet				
	Low NFC plus fat	Low NFC	High NFC plus fat	High NFC	SEM
DMI (kg/d)	24.71	24.95	23.63	24.43	0.42
pH	6.82	6.65	6.62	6.60	0.08
NH3 (mg/dl)	22.65^{b}	25.63^{b}	14.22^{a}	16.02^{a}	0.73
Milk (kg/d)	34.71	32.52	34.43	34.40	0.68
Milk fat (g/kg)	34.18	33.24	30.61	32.43	0.12
Milk protein (g/kg)	33.16	33.43	32.34	33.44	0.49
SNF (g/kg)	89.08	90.75	90.00	89.57	0.86

Means within rows with different superscripts are significant different (P<0.05)

Conclusion The results indicated that decreased NFC content, due to the replacement of barley with cotton seed hulls, supported a DMI, milk production and composition equivalent to high NFC diets. Therefore, it is economically favourable to use cotton seed hulls to replace a portion of barley in diets for lactating dairy cows without detrimental effects on DMI and performance.

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Production response of lactation dairy cows fed diet containing tropical lucerne silage

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Introduction There has been a special interest in legume silage research, not only they can provide high level of protein of plant origin, but also these silages are the most difficult to ensile. This is due to their low sugar content, high buffering capacity, high protein and high moisture content (Broderick et al., 2000). The aim of the present study was to evaluate the response of lactating cows fed diets containing tropical lucerne silage treated with sulphuric acid (SA) and urea (U).

Materials and methods Second – cut tropical lucerne (about 30% DM) was chopped and ensiled with urea (0.0 and 0.5% of DM) and sulphuric acid (0.0 and 0.6% of DM). The treatments were lucerne silage (LS), LS+ 0.5% U (LS+U), LS + 0.6% SA (LS+SA) and LS + 0.5% U + 0.6% SA (LS+U,SA). The chemical composition of the silages was determined after 40 days of ensiling. Eight Holstein lactating cows (second lactations) averaging 90 ± 24 DIM, 28 ± 5 kg/d milk yield and 575 ± 52 kg of BW were used in a Latin Square design (with two blocks); with four periods which each period consisted of 21 d. Animals were fed with a mixed ration (*ad lib*) twice a day. The experimental diets were formulated (DM basis) to contain 29.9% lucerne silage, 6.9% chopped lucerne hay, 27% corn silage, 1.84% wheat straw and 33.8% concentrate consisted of barley grain, wheat bran, soybean meal, cottonseed meal, beet sugar pulp and vitamin premix. Cows had free access to water and salt throughout the study. Milk yield was recorded daily. Samples of milk collected at the last day of each period. Blood samples were taken at 0.0, 2 and 4 h after the morning feeding at the last day of each period. Chemical composition of the silages and milk composition were determined using standard methods (AOAC, 1992). Data were analysed using the GLM procedure of SAS.

Results Chemical composition of the silages is shown in Table 1. Dry matter intake, milk yield, milk composition and blood metabolites concentrations were not affected by the treatments (Table 2.).

Table 1 Chemical composition (g kg^{-1}) of tropical lucerne silage treated with urea and sulphoric acid

Treatment	DM	CP	NDF	ADF	NPN	NPN/N	NH3-N	pH
LS	306	197	500	350	20.4	0.63	9.25	4.65
LS+U	290	184	600	380	15.74	0.53	8.14	4.94
LS+SA	291	203	480	330	17.76	0.55	4.04	4.3
LS+U,SA	313	175	560	360	14.11	0.5	7.6	4.63

Table 2 Dry matter intake, milk yeild, milk composition and blood metabolites of cows fed diets containing tropical lucerne silage treated with urea and/or sulphoric acid

		Treatments					
Item		LS	LS+U	LS+SA	LS+U, SA	SEM	*P*
Dry matter intake (kg/day)		22.8	23.6	23.0	23.9	0.62	ns
Milk production (kg/day)		27.6	27.6	27.9	28.5	0.65	ns
Milk CP (g/kg)		33	33	32	32	0.57	ns
Milk NPN (g/kg)		0.32	0.34	0.33	0.35	0.02	ns
MUN (mg/dl)		17.4	18.5	13	15.5	1.92	ns
Milk DM (g/kg)		115	116	117	118	1.08	ns
Glucose (mg/dl)							
Time(h)	0.0	70	65	77	75	7.50	ns
	2.0	74	81	74	82	9.00	ns
	4.0	70	78	77	90	9.20	ns
Urea nitrogen (mg/dl)							
Time(h)	0.0	19	17	14	16	3.00	ns
	2.0	17	19	21	18	2.86	ns
	4.0	20	22	19	23	2.30	ns

ns: P>0.05

Conclusions The results of the current study indicated that the tropical lucerne silages treated with sulphuric acid had better chemical composition compared to non-treated silage. Acid caused to decrease the CP hydrolysis to NPN during fermentation. Milk yield and milk composition responses were not influenced by the diets containing tropical lucerne silage treated with urea or urea and sulphuric acid. The results of the present study indicated that the replacing lucerne hay with lucerne silage might be an alternative in lactating cow diets as the milk production, its composition and the blood metabolite concentrations were not significantly influenced by the experimental diets.

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Effects of maize silage treated with urea and sulphuric acid on intake and milk production of lactating cows

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Introduction It is well known that milk production and its composition is highly correlated to the amount of energy consumed by lactating cows. Maize silage is an ideal forage for dairy cow diet in the developing countries located in the tropical areas. Maize silage is an excellent source of energy. However, its low nitrogen concentration is a limited factor for high producing dairy cows. The objective of the present study was to evaluate the effect of maize silage treated with urea (U) and sulphuric acid (SA) on lactating dairy cow performance.

Material and methods Whole maize hybrid was chopped and ensiled with U (1.6 % of DM, MS+U) or U and SA (1.6% of DM urea and 0.6% of DM SA, MS+U,SA). Twelve Holstein cows (DIM 76±5) were used in a complete random design for 7 weeks. The first week data were used as covariate for whole experimental data analysis. Animals were fed with a total mixed ration (17.5% CP, 11.2 MJ/kg ME) consisted of: 14.4% MS, 22.6% lucerne hay and 62.9% concentrate. Samples of milk were collected at the end of each week. The samples were analysed for protein, fat and milk urea nitrogen (MUN). Blood samples were taken via jugular vein at the middle and the last day of the experiment at 0.0, 2 and 4 h after the morning feeding. Blood samples were analysed for glucose and blood urea N (BUN). Data of milk production were analysed as repeated measures in time using the GLM procedure of SAS. Blood data were analysed as a completely randomized design using the procedure of SAS.

Result Data of milk production and milk composition are shown in Table 1. Results of blood metabolites are shown in Table 2. Milk yield (kg/d) and milk composition [fat (g/kg), CP (g/kg) and MUN (mg/dl)] and blood metabolites were not affected by the treatments. The influence of time (3rd, 5th and 7th week of the experimental period) on MUN (13, 12 and 14 mg/dl, respectively), milk CP (25, 29 and 32 g/Kg, respectively) and milk fat (27, 31 and 24 g/Kg, respectively) was significant ($P<0.05$). There was no treatment/time significant interaction.

Table 1 Milk yield and milk compositions of lactating cows fed diets containing maize silage treated with urea or urea+ sulphuric acid

	Treatments				
Item	MS+U	MS+U,SA	SEM	*P-value (Treatments)*	*P-value (time)*
Milk yield (kg/d)	30	35	4.20	0.94	0.24
Milk fat (g/kg)	26	26	0.70	0.71	0.01
Milk CP (g/kg)	29	28	0.30	0.17	0.01
MUN (mg/dl)	13	13	0.02	0.36	0.01

Table 2 Blood metabolites of lactating cows fed diets containing maize silage treated with urea or urea+ sulphuric acid

		Treatments			
Item	Time (h)	MS+U	MS+U,SA	SEM	*P-value*
BUN (mg/dl)	0.0	17	17	0.23	> 0.05
	2.0	20	18	0.18	> 0.05
	4.0	23	21	0.23	> 0.05
Glucose (mg/dl)	0.0	65	62	0.45	> 0.05
	2.0	56	59	0.37	> 0.05
	4.0	66	67	0.42	> 0.05

Conclusions The result of the present study indicated that milk yield in cows fed diet containing maize silage treated with U and SA were higher than those fed with diet containing MS treated with only U. Therefore it has been suggested that the nutritional value of maize silage in lactating cow feeding might be increase when it has been treated with the mixture of U and SA. The addition of urea either alone or with SA to the MS fed to the lactating cows didn't affect on blood metabolite concentrations.

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Effect of yeast culture on feed intake and productive performance of lactating dairy cows fed on barley silage based diets

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Introduction Pervious studies have suggested that yeast culture supplementation may have a significant impact on the productive performance of lactating cows. Improvements in dry matter intake (williams et al.,1991), milk yield (wohlt et al.,1991), milk fat and milk protein percentages have been reported in various studies (Harris et al.,1992). However, some studies have shown no significant response in lactating cows fed diets with yeast supplementation (Kim et al.,1992). The objective of this study was to evaluate the impact of diet supplemented with *saccharomyces cerevisiae* upon milk production and milk composition of early lactating Holstein cows.

Materials and methods Eight multiparous Holstein cows were randomly asigned to four dietary treatments. The statistical experimental was a balanced change-over design in four periods of 21 days.The main diets cnsisted of (DM basis) lucern (20%), barley silage (13%) and concentrate (67%) which has 7% whole cottonseed. In the experimental diets, saccharomyces cerevisiae was top-dressed to the main diet in a concentration of 0.0, 15 , 30 and 45 g/d/cow (the inclution rate was 5 g/d during adaptation periods). The yeast culture supplement contained $2x10^{9}$(cfu/g) live yeast (*saccharomyces cerevisiae*) cells per gram .Daily milk yield and feed intake were recorded weekly and sampled in a regular basis. Data for dry matter intake(DMI), feed efficency (milk/DMI), milk yield, milk composition and blood metabolites (samples of jugular vein taken) were analysed using GLM procedure of SAS (SAS Inc.,1986).

Table 1 Dry matter intake, milk yield and milk composition of lactating cows fed diets supplemented with Saccharomyces cerevisiae two hours after the morning feed .

Item	Yeast (g/d)				SEM	Statistical Significant
	0	15	30	45		
Dry matter intake(kg/d)	22.6	22.7	22.5	22.4	0.47	ns
Feed efficency	1.49	1.43	1.41	1.41	0.03	ns
Milk yield (kg/d)	33.30	32.65	31.85	31.80	0.47	ns
Milk fat%	3.26	3.20	3.28	3.38	0.13	ns
Milk protein %	3.03	3.00	2.89	2.97	0.0	ns
Milk lactose %	4.42	4.43	4.38	4.41	0.04	ns

ns $p>0.05$

Table 2 blood metabolites of lactating cows fed diets supplemented with saccharomyces cerevisiae

Item	Yeast (g/d)				S.E.M.	Statistical Significant
	0	15	30	45		
Glocose of blood (mg/dl)	52.74	52.42	53.01	52.15	4.88	ns
Urea-N (mg/dl)	23.69	20.62	21.16	22.69	0.98	ns

ns $p>0.05$

Results Result of dry matter intake, feed efficency, milk yield, milk composition and blood metabolites of lactating cows fed diets supplemented with *saccharomyces cerevisiae* are shown in Table 1. cows in treatment b (15 g/d) showed higher non significant intake . Mean daily milk production by the cows in treatments a ,b ,c and d were 33.30, 32.65, 31.85 and 31.80 kg, respectively. Generally, milk composition including fat, protein and lactose were similar in samples obtained from the experimental animals.

Conclusions Result of the present study showed that there is not a benefit to supplement the diet of high performance lactating cows with *saccharomyces cerevisiae*. This may related to the yeast strain or yeast concentration used in the present study. However, the basal diet and its composition might influence the animal responses. Therefore, the concentration of the impact of basal diet and its ingredient on yeast supplementation in lactating cows have been proposed.

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Chemical composition of wilted and unwilted lucerne silage treated with formic and sulphuric acids

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Introduction Ensiling of forage rather than drying for hay become more common in many area where drying is difficult. In addition, in some area that the weather condition is suitable for drying forage, because of the field losses, molds and the other risks, the ensiling of lucerne is common. Applying chemical preservations to unwilted silage may affect proteolysis in lucerne and bring about response, similar to that of wilting and so the risk of filed losses and lowered nutritive value of crop. Lucerne protein is subject to extensive degradation during ensiling. As much as 75% to 87% of total N in lucerne silage maybe NPN. The objective of the present study was to determine the effect of formic and sulphuric acids on chemical composition of lucerne silage ensiled at 2 different dry matter content (22% and 33%).

Materials and methods Fourth cut lucerne was harvested , chopped (1.5 cm) and ensilaged in laboratory silos without wilting (22% DM) and with wilting for 12 hours (33% DM). The levels of formic acid were 0.0, 5, 10, 15 and 20 ml/kg DM and sulphuric acid levels were 0.0 and 0.4%, DM. The silages were kept at ambient temperature. After 40 days the silos were opened and were analysed for pH, CP, True protein (TP), NPN and NH3-N. For determination the pH, a sample of 50 grams was placed in a beaker with 450 ml of water and pH measured in the extract with a portable Metrohm pH meter. The Kjeldal method was used for N determination (Tecator 1030). Data were analysed in a completely randomised design using GLM procedure of SAS (SAS Inc.,1986).

Results Chemical composition of lucerne silages shown in Table 1. The effect of wilting on pH was significant (P<0.05). The formic acid caused to increased the CP concentration of lucerne silages (P<0.05).

		S2				F [1]					DM		
P	MSE	0.4	0	*P*	MSE	20	15	0	*P*	MSE	33%	22%	Item
0.27	0.14	5.32	5.12	0.06	0.27	4.91	5.45	5.29	0.01*	0.12	4.95	5.12	pH
0.40	0.21	186	183	0.01*	1.32	187	196	170	0.10	0.35	187	182	CP (g/kg)
0.84	0.07	120	119	0.58	0.3	123	117	120	0.79	0.07	119	120	NPN (g/kg)
0.26	0.28	62.1	66.3	0.57	0.24	66.7	64.1	61.8	0.13	0.77	66.1	55.1	TP (g/kg)
0.38	0.7	14.1	13.1	0.10	1.6	11.8	14.9	14.3	0.68	0.28	13.4	13.8	NH_3-N(mg/dl)
0.52	0.007	440	430	0.61	0.005	430	440	430	0.39	0.005	437	444	NDF (g/kg)

Table 1 Chemical composition of lucerne silage treated with formic and sulphuric acids at 2 different DM content
1 Formic acid levels (ml/kg, DM)
2 Sulphuric acid Levels (%DM, vol/Kg)
* P<0.05

Conclusions The pH was lower in the wilted lucerne silage than the unwilted silage (P<0.05). This may be due to the fermentation of carbohydrates to organic acids during wilting. The greater amount of protein (P<0.05) in the formic acid treated silages could supposed this theory that rapid decrease in pH can inactivate the plant cells proteolytic enzymes activity. In addition, wilting result in increasing CP and TP. The wilted silages had lower NH_3-N concentration than unwilted silage that was previously reported by Muck (1987).

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The effect of corn silage treated with urea and ammonia on milk production and composition in early lactation Holstein-Friesian cows

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Introduction: corn silage use in large industrial farm for dairy cows but it is low in protein .ammonia and urea has been used for increase the N content of corn silage. Also it seems are they can increase milk production in cows. Ammonia can increase true protein of silage and it has mould killed properties in silage and can delay the growth of mould and yeast in opened silages. Ammonia can increase butyric acid content in silage so increase milk fat in dairy cows.

Materials and methods: eight Holstein-Friesian cows in replicate 4×4 Latin square were used in current study. Cows had a mean DIM 54±19 and the average milk production was 33±5 kg/d.The cows were fed total mixed ration with 60% concentrate(C) and 40% roughage (20%alfalfa+20%corn silage). Experiment had 4 treat include:1)corn silage without supplementation(CS) 2)CS+0.6%urea 3)CS+0.33%ammonia(AM) 4)CS+0.33%AM+0.1%gysum(G)(the rate of C and alfalfa in all treated was stable).the experiment was conducted in four period. Each period contain 14 days for adaptation and 7 days for collection .dry matter intake(DMI),organic matter digestibility, rumen pH and milk yield were analysis during collection period(according standard method AOAC).

Results: Chemical analysis demonstrated OMD in 3 treat (CS+0.33%AM) was the highest and in 2 treat was in least. Milk production in 2,3and 4 treats was higher.DMI in 3and 4 treats was higher than in 1 and 2 treats with significantly different. Rumen pH in 3and4 treats are higher than 1and 2 treats with significantly different.

	T1	T2	T3	T4	MSE
DMI	$24.94^{a,b}$	24.62^{b}	25.69^{a}	25.81^{a}	0.643
OMD	$0.792^{a,b}$	0.773^{b}	0.799^{a}	$0.787^{a,b}$	0.0003
Rumen pH	6.65^{a}	$6.312^{a,b}$	$6.218^{a,b}$	6.079^{b}	0.205
Milk	31.0^{b}	34.75^{a}	$33.375^{a,b}$	34.00^{a}	5.836
DCP	0.802^{a}	0.79^{a}	0.802^{a}	0.793^{a}	0.0005

Conclusion: The result of the present study demonstrated that ammonia use in corn silage increase milk production, milk fat and has higher DMI and OMD in dairy cows. Also ammonia can delay the spoilage in opened silage.

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Effect on dry matter intake and milk production in lactating cows fed diets containing lucerne silage treated with HCl

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Introduction Greater feeding value of lucerne silage (LS) than Lucerne hay has been a common finding of ruminant feeding studies in tropical countries. There are lower field losses and weather damage when lucerne (L) has been ensiled compared with lucerne hay. However, during ensiling, much of the crude protein (CP) of L is broken down to non protein nitrogen (NPN). Additives such as HCl may reduce proteolysis during L ensiling. More recently, work conducted with LS, indicated that LS improved milk yield. The objective of the present study was to examine the effect of diets containing LS treated with HCl and urea on feed intake and milk production of fresh cows (cows with DIM<30 days).

Materials and methods Lucerne (27% DM) was harvested, chopped and mixed with different levels of HCl and urea, then ensiled for 40 days. The treatments were LS, LS treated with urea (0.5% of DM) and HCl (0.4% of DM), (LSu_1+a_1), and LS treated with urea (0.5% of DM) and HCl (1.2% of DM), (LSu_1+a_2). HCl was carried and used under the safety protocol of Ferdowsi University of Mashad, using special instruments. The acid (37%) was diluted with water (acid:water 1:4, vol/vol) and stored in an artificial plastic container until it was mixed with the forage. Fifteen Holstein fresh cows (Mean ± SD) of 21 ± 3 DIM, 30.7 ± 6.9 kg/d milk were used in three groups (5 head per group) in a complete random design, for 7 weeks. The animals were fed with same ration in the first week, and the milk production data were used as covariate for the experimental data. The cows were fed with the same ration containing 37.4% forage (16.6% LS, 11.5% maize silage and 7.8% lucerne hay) and 62.6% concentrate, two times per day. Feed intake and milk production were recorded daily. The samples of milk were prepared at the end of 1st, 3rd, 5th and 7th week of the experimental period. Blood samples were taken at the last week of experiment at 0.0, 2, and 4 h after the morning feeding. Milk protein and urea-N were determined using the standard procedures (AOAC, 1980). The samples of blood were analyzed for glucose and N-urea using spectrophotometer procedures. Procedures of SAS were used to analyze data as a repeated measure in time which the statistical model was y = covariate + treatment + cow (treatment) + lactation week + treatment by lactation week, Where cow (treatment) = random effect used to test treatment. The residual error was used to test lactation week and the interaction of treatment by lactation week.

Results The results of DM intake, milk yield and the composition are presented in Table 1. Data of blood metabolites are shown in Table 2. Milk yield and milk composition were not significantly affected by the treatments (P>0.05). Milk yield was significantly affected by the experimental time (P< 0.05). Glucose concentration was higher in samples taken before the morning feed than 4 h after feeding.

Table 1 Milk yield and milk composition of lactating cows fed diets containing LS treated with urea and HCl

	Treatments			Treatment effect		Time effect	
Item	LS	LSu_1+a_1	LSu_1+a_2	SEM	*P-value*	SEM	*P-value*
DMI ($Kg/W^{0.75}$)	0.18^a	0.18^a	0.16^b	0.01	0.01	0.01	0.01
Milk (kg/d)	38.8	41.3	41.3	1.57	0.94	0.09	0.04
Milk protein (Kg/d)	1.37	1.42	1.35	0.40	0.95	0.01	0.14

Table 2 Blood metabolites (mg/dl) of lactating cows fed diets containing LS treated with urea and HCl

Item	Time (h)	Treatments			SEM	*P-value*
		LS	LSu_1+a_1	LSu_1+a_2		
BUN	0.0	16	15	15	0.13	0.74
	2.0	17	15	15	0.10	0.29
	4.0	15	15	15	0.09	0.99
Glucose	0.0	71^a	68^b	74^c	0.20	0.01
	2.0	70^a	70^a	74^b	0.12	0.01
	4.0	69	69	72	0.22	0.45

Conclusion Results of the present study showed that milk yield was not significantly influenced when cows were fed with diets containing LS treated with HCl compared with the non-additive LS. When diets containing LS treated with HCl were fed to the cows, dry matter intake was lower than that of non-treated LS. This may be related to the DM degradability of the HCl treated silages. Overall, the results of the present experiment suggested that diets containing LS treated with HCl had a non-significant effect on milk and milk protein yields.

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Effect of short term injection of human somatotropin in early lactating dairy cows.

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Introduction Bovine somatotropin is a peptide hormone that produced in anterior pituitary gland and released under the influence of growth hormone releasing factor. Somatotropin release can be inhibited by somatostatin a 14 amino acid peptide hormone. Since the early 1980s larg amount of highly purified somatotropin have been produced, using recombinant DNA methods. Somatotropin has been short- and long-termeffects on metabolism that booth coordinate and result from its stimulus to milk production. Bovine and human somatotropin (hST) are about 65% homologus and not simillar enough for recombinant bovine somatotropin (rbST) to be active in human if injected[1]. It is unclear that human somatotropin can bind with bovine growth hormone receptors and produce the physiological effects? The goal of this experiment is try to indicate the probable physiological effects of hST in dairy cows.

Material and methods Ten Holestein-Friesian dairy cows were divided between two groups that the days in milk, calving date, and milk production was similar. The cows fed twice daily at 0900 and 1600 h. Treatment include 5, 10, 15, (mg/d) human somatotropin and control cows recive 10 (ml/d) physiologic serum. Ration formulated according to NRC (2001) nutrient requirements for high milk yield. Milk samples were collected daily and sample were analysed for fat, protein, and lactose. Composition of feed was analysed for ADF, NDF, Ca, and P. Plasma samples were collected daily from Jugular vein 2 hours after feeding. Samples were analysed for Insulin and glucose. Data were analyzed by T-test with using of SAS (SAS Inc.,1986).

Result Data for the experiment are given in table 1. There was positive but nonsignificant correlation between hST injection and milk production. Effect of hST was not significant for fat percentage, protein percentage, feed intake, serum insulin and glucose.

Table 1

			rhST (mg/d)				
Item	Control	SEM	5	10	15	SEM	P
Milk							
MY (kg/day)	35	0.6	35.2	37.9	37.5	1.4	ns
Fat %	3.9	0.3	3.73	3.45	3.5	0.15	ns
Protein %	3.3	0.08	2.98	2.89	3.2	0.16	ns
Blood							
Glucose (ml/dl)	52	0.4	54.3	55.5	55.9	.083	ns
Insulin (µIU/ml)	9.5	0.3	8.9	9.4	9.2	0.25	ns

Conclution The results of present study demonstrate that short-term injection of hST did not improve the significant increase in milk and milk component, because of positive correlation between milk production and hST treatment that appear in this experiment. We suggest that the same study could be conducted with more cows and higher doses of the hormone.

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Variation in the milk yield response to bovine growth hormone in dairy cows

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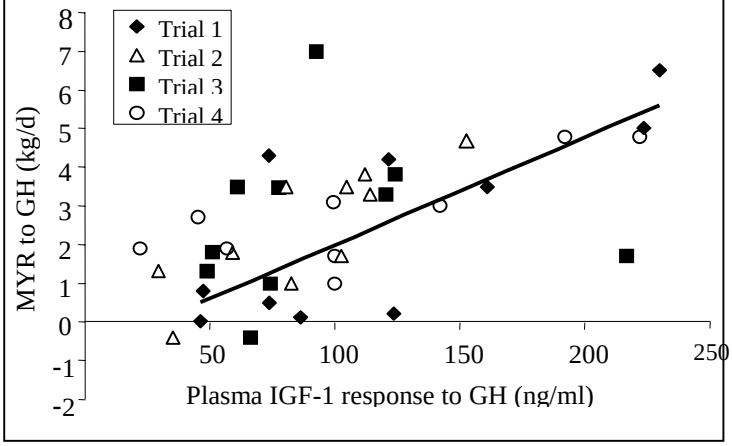
Introduction Considerable variation has been observed between studies investigating the milk yield (MY) response (MYR) to exogenous growth hormone (GH) in dairy cows. Daily injections of 25 mg/day of the recombinant product caused a MYR of over 10 kg/d (Bauman *et al.* 1985), a level of response rarely repeated since. Other studies using apparently similar doses and management regimes have reported no substantial effect of the hormone on MYR (e.g. Hof *et al.* 1991). While these studies are extreme examples, it is clear that variability in MYR has occurred between trials. In contrast, relatively little information has been published concerning variation in the MYR between treated cows. Indeed, the notion of individual variation in the MYR to GH remains contentious: Bauman (1992) suggested that the variation in the MY of GH treated cows was similar to that of control cows, and that variation in the MYR between individuals does not exist. The object of this experiment was to investigate the extent of the individual variation of the MYR to GH in dairy cows, and to relate this to changes in plasma concentrations of hormones and metabolites.

Materials and methods Twenty-four, autumn calving, multiparous, Holstein-Friesian cows were used (Trial 1). They were on average 52 ± 4.1 days *post partum*. During week 1, each cow received a subcutaneous injection of phosphate buffered saline (PBS) daily. During weeks 2 and 3 the cows received daily injections of 33 mg/day of GH dissolved in the PBS. The MYR of each cow to the GH was defined as the difference in average MY (kg/d) between the first week and the third week of Trial 1. The five cows with the highest MYR to GH (HR) and the five cows with the lowest MYR to GH (LR) from this trial were used in a series of three further experiments (Trials 2, 3 and 4, respectively), conducted when these cows were on average 122, 181, and 237 ± 7.6 days post partum. The further trials were of the same design as Trial 1. During Trials 1 and 2 the cows were housed and fed concentrate (at a rate according to MY and body condition) and silage. During Trials 3 and 4, the cows were at pasture. Venous blood samples were taken by venipuncture on days 1, 3, 5, 8, 10, 12, 15, 17 and 19 of all four trials, at 0830, 2 hours after the injection of the PBS/GH. Plasma was analysed for GH, IGF-1, 3-hydroxy-butyrate (3-OHB) and non-esterified fatty acids (NEFA). Repeated measures analysis was conducted using REML (Genstat) with trial number nested within cow and a compound symmetry or autoregressive model fitted, as appropriate.

Results The HR group gave an average of 4.7, 3.9, 4.7 and 3.7 kg/d more milk, respectively, in week three than week one of Trials 1, 2, 3 and 4; the LR group gave an additional 0.3, 1.4, 1.5 and 1.5 kg/d, in each trial, respectively (SED: 0.75). The LR group had a higher initial MY in the PBS treatment week throughout the trials (20.2 and 24.9 kg/d for the HR and LR groups, respectively; $p<0.05$, SED: 2.21). The average increase in plasma GH concentrations following GH treatment was greater for the LR group (30.4 and 49.1 ng/ml for the HR and LR groups respectively; $P<0.001$; SED: 4.17), while the increase in the concentrations of IGF-1 following GH treatment was greater for the HR group (132.8 and 62.9 ng/ml, respectively; $P<0.001$; SED: 11.0). There was a positive correlation across all trials between MYR and the increase in the concentration of IGF-1 (Figure 1).

Figure 1. Relationship between MYR to exogenous GH and the plasma IGF-1 response to the GH
$y = 0.03x - 0.80$; $r^2 = 0.59$



The HR group also had significantly greater concentrations of IGF-1 before GH treatment (90.13 and 63.1 ng/ml for the HR and LR groups respectively; $P<0.001$; SED: 6.4). During saline treatment, the HR group had significantly lower levels of 3-OHB (0.549 and 0.756 mmol/l, respectively; $p<0.001$; SED: 0.03) and NEFA (0.121 and 0.166 meq/l, respectively; $p<0.001$; SED: 0.008). The increase in the plasma NEFA levels following GH treatment was significantly greater for the LR group (0.163 and 0.208 meq/l, respectively; $p<0.05$: SED: 0.024).

Conclusion The average MYR to GH in early lactation was similar to that observed in later lactation for both groups of cows. Poor short-term response to GH was associated with plasma concentrations of hormones and metabolites that indicated a greater negative energy balance; this was the case throughout lactation. The HR group appeared to have greater rates of GH clearance and either greater rates of IGF-1 secretion, or slower rates of IGF-1 clearance.

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Establishment, characterisation and mammary specific function of a bovine mammary epithelial cell clone cultured on reconstituted basement membrane

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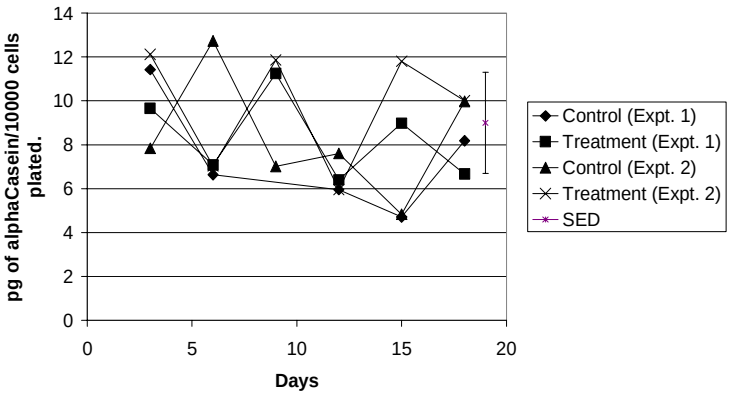
Introduction Mammary gland development and lactation are complex processes, predominantly governed by the reproductive state of the female. The many hormones, growth factors and cell types make the *in vivo* elucidation of the roles of these factors in mammary development and lactation difficult. Therefore, an *in vitro* model would be very useful. A step towards this goal was demonstrated when a mammary epithelial cell (MEC) clone was isolated by limiting dilution methodology, and morphological and functional differentiation on a reconstituted basement membrane was brought about (Rose *et al.* 2002). The aim of this study was to build upon these earlier observations, and establish a representative model of the bovine mammary gland using a MEC clone capable of mammary specific function.

Materials and methods A primary culture was derived from mammary tissue obtained from a fifth lactation Holstein Friesian dairy cow (200d post partum), using methods described by Rose *et al.* (2002). A mixed cell monolayer culture was established. Cultures were passaged every four days and limiting dilution methodology was employed to derive clonal cell populations. One clone was selected for characterisation and morphological and functional differentiation. Characterisation included proliferation assays and DNA accumulation for passages 10, 11, 13, and 15, evaluation of genetic normality, and immuno-staining of cytoskeletal proteins. The ability of the MEC clone to undergo morphological and functional differentiation was investigated by culturing 2.5 x 10^5 cells/cm^2 on reconstituted basement membrane coated dishes (Fahrenheit, Milton Keynes, UK), in Dulbecco's modified Eagle medium supplemented with 1% foetal bovine serum (Invitrogen Ltd., Paisley, UK) (Control). Treatment cultures included the addition of lactogenic hormones (prolactin 5µg/ml, dexamethasone 5µg/ml and insulin 5µg/ml) (Sigma, Poole, Dorset, UK). In Experiment 1, Control and Treatment cultures consisted of three replicates, and this was wholly repeated on another occasion (Experiment 2). The culture media were changed every 3 days and stored frozen at -80^{o}C. Luminal fluid was extracted on day 18 of culture, according to the method of Barcellos-Hoff *et al.* (1989). The experiment was subsequently terminated by removal of the cells from the basement membrane following trypsinisation. Lumen fluid and cells were stored at -80^{o}C. Morphological differentiation was evaluated visually, whereas functional differentiation was evaluated by measuring the concentration of α-casein in media collected on days 3, 6, 9, 12, 15 and 18 and the concentration in lumen fluid. The concentration of α-casein was determined using a sandwich ELISA. Effects of experiment and treatment on lumen α-casein levels were evaluated using ANOVA after square root transformation to account for a skew in the data. Media α-casein concentrations were analysed by fitting experiment, treatment and day nested within plate using a REML algorithm to account for missing data for the control on day 9 of Experiment 1.

Results Characterisation confirmed the epithelial nature of the MEC clone. When plated on reconstituted basement membrane, three-dimensional structures were apparent in both control and treatment cultures by day 9 of the experiment. These structures were presumed to be alveolar in nature. Both treatments stimulated the secretion of α-casein into the culture media in both experiments (Figure 1). However, there were no significant differences in media α-casein concentrations on any of the 5 days (P>0.05; SED: 2.30). Although luminal α-casein concentration was higher in Experiment 1 (P=0.03), there were no differences between treatments within experiment (Back transformed values; treatment: 9.06 pg/10000 cells, control: 16.62pg/10000 cells; P=0.410)

Figure 1. Supernatant media α-casein concentrations for control and lactogenic hormone treated cells in Experiments 1 and 2



Conclusion The ability of cells to synthesise α-casein was not confined to those cultured in the presence of lactogenic hormones. These results suggest that *in vitro* the extra cellular matrix is a key mediator of α-casein expression. However, the lack of response to lactogenic hormones puts into question the usefulness of this MEC clone as a representative model of the mammary gland. Results from this experiment warrant further investigation, in particular to investigate the role of the extra cellular matrix and lactogenic hormones on alveolar morphogenesis and α-casein gene expression.

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Effects of daidzein on metabolic hormones in plasma during perinatal period in dairy cows

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Introduction Daidzein, an isoflavonic phytoestrogen, is presented in bean legumes (Zheng *et al*, 2002). Feeding the isoflavons-containing herbage can promote udder growth and lactation in sheep and cow (Millington, 1964). The diets with daidzein added prompt growth development and lactation in rats, pigs, and sheep, which is possibly due to the effect of daidzein on the endocrine system and metabolism (Han, 1999). The objective of this study is to determine the effect of daidzein on the plasma contents of some hormones in first foetus dairy cows.

Materials and Methods Twelve first foetus Holstein dairy cows, which were supplied by the Xinhuo second dairy farm of Shanghai Bright Dairy & Food Co., Ltd, were used in the study. The experiments consisted of control and treated phases. The daidzein was added into the feed at a dosage of 80 mg/d·body 10 days before parturition. All blood samples were collected *via* the superior vena cava. Heparin was added and samples immediately centrifuged at 4C. The plasma was separated and stored at –30C and analyzed by radioimmunoasssay (RIA). The RIA kits for T_3, T_4, TSH and Insulin analysis were supplied by Shanghai Biological Product Institute, Health Ministry (Shanghai).

Statistic analyses The data were presented as $\bar{X} \pm SD$. The significances of differences between mean values were determined using student's t test.

Results The plasma contents of metabolic hormones were shown in table 1.

Table1 Effects of daidzein on metabolic hormones in plasma during perinatal period in cows

Item	Control	Treatment			
		D7 after treatment	D3 after parturition	D10 after parturition	D17after parturition
T_3 ng/ml	1.62 ± 0.46^{Aa}	1.17 ± 0.45^{B}	1.42 ± 0.45^{c}	1.37 ± 0.48^{c}	1.97 ± 0.45^{bD}
T_4 ng/ml	38.51 ± 20.42^{A}	25.20 ± 21.27^{B}	30.77 ± 5.38^{c}	34.88 ± 11.31^{C}	28.99 ± 18.10^{B}
TSH μIU/ml	2.29 ± 0.28^{a}	1.96 ± 1.00^{b}	2.17 ± 0.27^{ab}	2.29 ± 0.32^{ab}	2.23 ± 0.27^{ab}
Insulin μU/ml	9.48 ± 2.26^{a}	7.84 ± 0.33^{b}	9.66 ± 3.91^{a}	9.42 ± 2.41^{a}	8.21 ± 0.59^{b}

$^{A-D}$Represents the significantly differences ($p<0.01$) between the value of control and that of the treatment in the same row with different superscripts.

$^{a-d}$Represents the significantly differences ($p<0.05$) between the value of control and that of treatment in the same row with different superscripts.

T_3 and T_4 content in plasma could feedback TSH level. Compared with the control, the plasma contents of T_3 in day 7 after treatment, day 3 and 10 after parturition were significantly ($P<0.05$) lower than that of day 10 of expected date of calving (control). During the experiment period, the plasma contents of T_4 were decreased markably ($P<0.01$), except in day 10 of expected date of calving. The plasma content of TSH in day 7 was decreased by 14.41% ($P<0.05$). This suggests that T_4 was transferred into T_3 by 5'-monodeiodinase in liver and TSH and thyroid affect each other in body. . In this test, the insulin contents in day 7 after treatment and day 17 after parturition were significant lower than that of control ($P<0.01$).

Conclusions The results show that the daidzein affects the contents of metabolic hormones, influences the nutrients transform, including anabolism and decompose, and further helps Holstein cows to adapt to perinatal physiological changes.

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The effect of moisture, freezing and sample shape on the punch resistance and elastic modulus of the bovine hoof horn

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Introduction Mechanical properties of the hoof horn such as hardness, elastic modulus, bending stiffness and fracture toughness were influenced by the moisture content of the hoof horn (Collins et al., 1998; Baillie et al.; 2000). The moisture content of the hoof horn has been found to be affected by the micro-architecture and biochemical composition of the horn and by external factors such as humidity, chemicals and microbiological factors (Budras and Mulling, 1998). The aim of the experiment was to determine the influence of the moisture content and of storage methods, such as refrigerating in plastic bags and freezing, over the punch resistance and elastic modulus of the bovine hoof horn. Storage methods were studied for the determination of an experimental protocol in further research.

Materials and methods The hooves of six beef cattle, aged between 24 and 28 months, were obtained from an abattoir. On the same day of collection samples were taken from areas 5 and 2 of the sole of each claw, corresponding to the International Foot Map. They were kept in sealed plastic bags at room temperature until conditioning or analysis at the same day. The first batch of samples of all claws was kept in environments containing relative humidities (RH) of 11, 33, 58, 75 and 97% for 7 days. Samples from each hoof were tested thereafter 12 times for punch resistance (PR) and elastic modulus (EM) on a Texture Analyser (Stable Micro-Systems). Data from sole and white line areas were recorded separately. After the tests were completed the dry matter (DM) of the samples was determined. A second batch of samples, with physiological moisture content, was tested at the same day to determine the effect of sample thickness on PR. The thickness varied between 0.05 and 0.3 mm. Further samples were tested for the effect of storage duration in plastic bags and of freezing on DM and mechanical properties. For the testing of the effect of storage 6 samples of each claw were placed in self-sealed plastic bags and stored at a temperature of 2°C. Samples were tested for punch resistance and elastic modulus at 0, 48, 96, 144 and 192 hours. For the testing of the effect of freezing samples were tested on the same day of collection (not frozen) followed by which the samples were stored in a freezer (-20 ^{0}C) in 3 separate plastic bags. The first bag was taken out of the freezer on the following day and left to defrost at room temperature for 4 hrs. Mechanical tests were completed. After being stored for one week and for one month, the second and third bags were taken out of the freezer and mechanical tests were completed. Effects of RH, DM and sample thickness were analysed by regression analysis. The data from the time stored in plastic bags and freezing tests was analysed in ANOVA – GLM (Minitab 13.0) for the effect of treatment and means were compared using the Tukey test .

Results Increase in DM resulted in a significant (P<0.01) linear increase in the PR (N) of the sole (PR= 0.4901 DM – 24.394, Rsq.= 0.54) and the white line horn (PR= 0.4301 DM – 24.874, Rsq.= 0.64) (Figure 1 and 2). The EM (N/mm^2) of the sole horn was significantly (P<0.01) positively exponentially related to the DM (EM= 0.0602e$^{0.1012x}$, Rsq.= 0.81). DM varied from 63.7 to 89.1%, PR of the sole horn from 6.24 to 24.66N, PR of the white line horn from 2.17 to 18.60N and EM from 85.5 to 751.9N/mm^2. The days (1 to 8) taken to analyse the samples and freezing for up to 30 days had no significant effect on the DM and PR of the sole and white line horn. There was a significant (P<0.01) increase in the EM of the sole horn when samples were frozen for 30 days. PR increased in a positive significant (P<0.001) linear way in relation to the thickness (mm) of the area tested (PR= 6.679 + 34.531 thickness, Rsq.= 0.66).

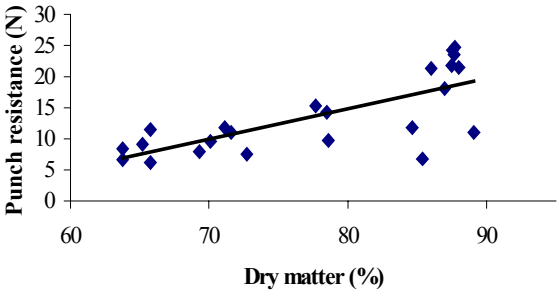

Figure 1 Effect of dry matter (%) on the punch resistance of sole horn samples

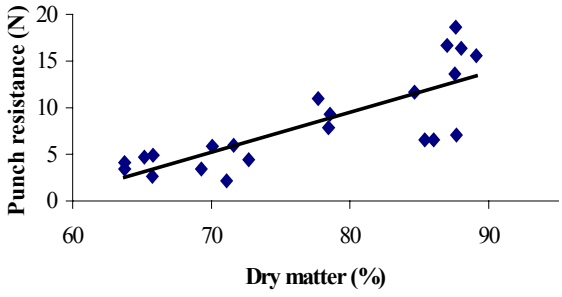

Figure 2 Effect dry matter (%) on the punch resistance of white line horn samples

Conclusions Punch resistance and elastic modulus were affected by the moisture content of the hoof horn in a similar way as other mechanical properties (Collins et al., 1998; Hinterhofer et al., 1998; Baillie et al.; 2000). Loss of moisture should be controlled. Thickness should be included as a covariant in the analysis of PR tests.

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The effect of moisture, freezing and sample shape on the punch resistance and elastic modulus of the bovine hoof horn

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Introduction Mechanical properties of the hoof horn such as hardness, elastic modulus, bending stiffness and fracture toughness were influenced by the moisture content of the hoof horn (Collins et al., 1998; Baillie et al.; 2000). The moisture content of the hoof horn has been found to be affected by the micro-architecture and biochemical composition of the horn and by external factors such as humidity, chemicals and microbiological factors (Budras and Mulling, 1998). The aim of the experiment was to determine the influence of the moisture content and of storage methods, such as refrigerating in plastic bags and freezing, over the punch resistance and elastic modulus of the bovine hoof horn. Storage methods were studied for the determination of an experimental protocol in further research.

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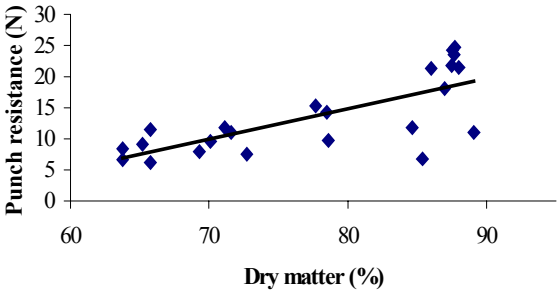

Figure 1 Effect of dry matter (%) on the punch resistance of sole horn samples

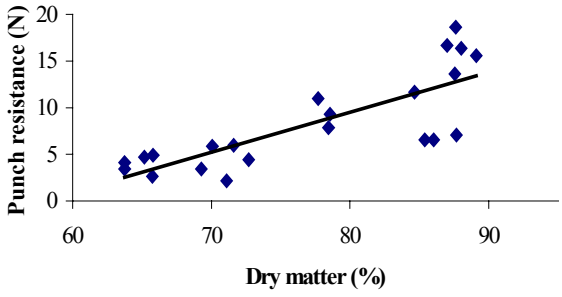

Figure 2 Effect dry matter (%) on the punch resistance of white line horn samples

Conclusions Punch resistance and elastic modulus were affected by the moisture content of the hoof horn in a similar way as other mechanical properties (Collins et al., 1998; Hinterhofer et al., 1998; Baillie et al.; 2000). Loss of moisture should be controlled. Thickness should be included as a covariant in the analysis of PR tests.

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Evaluation of selenium metalosate as an organic selenium source in dairy concentrate feed

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Introduction Selenium is an essential nutrient for dairy cattle, being a key component of the anti-oxidative protection mechanism. With over 20 seleno-proteins being identified in the body as important nutrients or co-factors for the physiological processes involving production, health and fertility, the need for ensuring a selenium supply which is both efficacious and safe has increased dramatically. Key roles of selenium include supporting the immune function and fertility. In terms of reproduction its main action is to protect the developing embryo from oxidative damage. Concern over the sufficiency of selenium supply has increased in recent years and it is well recognised that the British Isles is deficient in selenium as measured in soils and crops. As a consequence, the animal is totally dependent for its selenium supply on concentrated feedstuffs and mineral supplements. There is a cautious approach to dietary supplementation of selenium because of its toxicity even though a legal limit of 0.50 mg/kg in dairy complete feeds applies. It is also recognised that traditional sources of selenium (sodium selenite) have limited availability and utilisation within the animal. Considerable research effort has been directed at evaluating the key selenium metabolite "L-Selenomethionine" as a potential dietary selenium source. Much of the naturally supplied selenium from feedingstuffs is in this form. Supplying a significant proportion of selenium in the organic methionine form has been found to both reduce potential toxicity problems and boost absorption. The aim of this trial was to compare two selenium supplements, selenium selenite (inorganic) and selenium metalosate (organic) in the dairy cows diet and investigate effects on milk yield, milk composition and hygiene, and fertility.

Materials and Methods Two groups of 20 cows were assigned at calving to either a control or test group. The groups were balanced for parity, calving date and previous lactation yields. Both groups received an identical diet apart from the selenium source in the parlour concentrate (Premium Winter dairy concentrate, Pye Farm Feeds, Lancaster) which was sodium selenite (inorganic) for the control, and selenium metalosate (organic) for the test. Both were included at a level of 100g/tonne of concentrate. Target selenium intakes were 10mg/cow/day with 3.5mg/cow/day being supplied by the selenium sources in the parlour concentrate. All the cows received an identical TMR *ad libitum* of grass, maize, whole crop wheat and whole crop pea silage dispensed by mixer wagon. The trial ran for 14 weeks with comparisons between the groups being made for milk production, milk composition and hygiene and fertility. To monitor selenium status both blood Glutathionine Peroxidase (GSH-Px) and milk selenium levels were recorded.

Results First service conception rate improved from 28 to 44%, while first and second service conception rates rose from 50 to 67% which was significant at the $p<0.089$ level. The number of days open was reduced by 23 days and the number of services per conception dropped although this was not significant statistically. No significant differences ($P>0.05$) between the groups were found for milk yield, composition or hygiene, although cell counts were lower on the test treatment. There was an increased status in blood GSH-Px and milk selenium content reported at the end of the trial in the test group although these results were not significantly different ($P>0.05$).

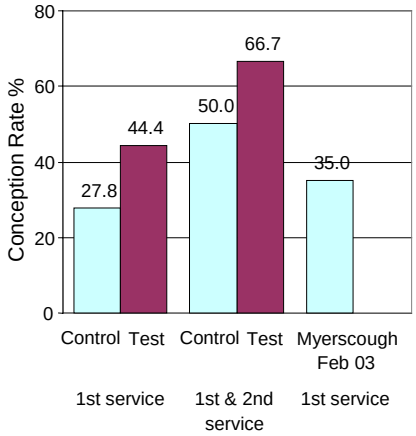

Figure 1. Conception rates

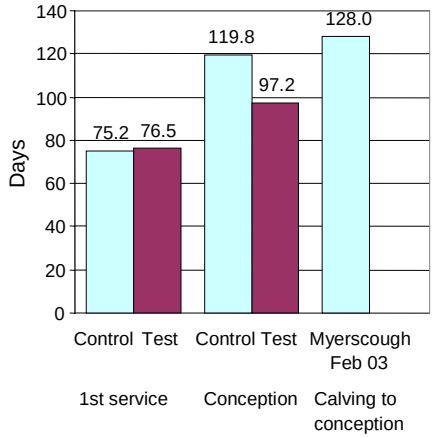

Figure 2. Days Open

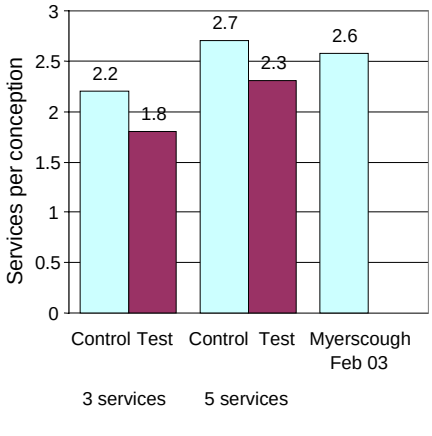

Figure 3. No. of services per conception

Conclusions There was no observed effect on milk production, milk quality and cell count levels suggesting that the trial cows were not selenium deficient although this was not the case when it came to fertility. The higher availability and utilisation of selenium metalosate clearly improved conception rates (see Fig. 1) to the overall benefit of herd fertility and profitability. Improving selenium dependent antioxidative protection to the developing embryo through the use of selenium metalosate is the most likely explanation for the observed reproductive response.

Metabolic and endocrine responses of mature and adolescent ewes to plane of nutrition during early pregnancy

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Introduction A high plane of nutrition during early gestation has a detrimental effect on the establishment of pregnancy in adolescent but not mature ewes. Elevated insulin levels in well-fed adolescent ewes have been implicated in maintaining the anabolic drive to maternal growth at the expense of foetal tissue synthesis (Wallace *et al.,*1997). The adipocyte hormone, leptin has effects on food intake, body weight stasis and the gonadotrophic axis and therefore may also, like insulin, be implicated in the establishment and success of pregnancy. The objectives of the current experiment were to investigate the effects of plane of nutrition in mature and adolescent ewes during the first month of pregnancy on changes in maternal concentrations of insulin, leptin and blood metabolites.

Materials and Methods Forty-two Greyface and Texel x Greyface ewes (liveweight: 71.8 s.d 5.2 kg; BCS: 3.74 s.d 0.3) and forty-eight Texel x Greyface ewe lambs (liveweight: 47.2 s.d 3.7 kg; BCS: 3.30 s.d 0.4) were mated to Texel rams and allocated to one of three treatments, balanced for liveweight and condition score. Eighteen hours after mating, animals were individually housed and placed on one of three dietary treatments (n=14 ewes, n=16 ewe lambs) estimated to supply 2.0 (H), 1.0 (M) and 0.6 (L) of daily maintenance ME requirements (Agriculture and Food Research Council, 1993). Treatments were imposed from day 1-31 of pregnancy using grass nuts (10.7 MJ ME/kg DM; 199 g CP/kg DM; estimated 'a' = 0.37 [AFRC, 1993]) offered at three different levels. Single point jugular blood samples were obtained at mating and twice weekly from day 1-31 of pregnancy, on average 2 hours 30 minutes post-feeding. Plasma was assayed for insulin and leptin by double-antibody radioimmunoassays. Concentrations of plasma β-hydroxybutyrate, non-esterified fatty acids (NEFA), albumin, globulin, total protein and urea were determined using a clinical analyser. Liveweight and body condition scores (BCS) were measured at mating and then weekly during the treatment period. Data were analysed using Repeated Measures REML analysis in a 3 (diet) x 2 (ewe maturity) factorial design.

Results Plane of nutrition in early pregnancy led to significant (P<0.001) changes in both liveweight and BCS between treatments (H > M > L). However, adolescent ewes were less sensitive than mature ewes to gain or loss of liveweight on the H and L treatments respectively (P<0.001). Adolescent ewes also maintained BCS (P<0.001) to a greater extent compared with mature ewes. Increasing the level of post-mating nutrition led to significant (P<0.001) increases in concentrations of insulin, β-hydroxybutyrate and urea and to a significant (P<0.001) decrease in NEFA concentration. Plasma insulin and leptin concentrations were higher (P<0.001) whilst NEFA levels were lower (P<0.01) in mature ewes compared with adolescent ewes during early pregnancy. Plasma leptin concentrations increased (P<0.001) linearly in mature ewes only, as the plane of nutrition increased while, in adolescent ewes, leptin concentrations were similar for M and L treatments and significantly lower (P<0.001) than for the H treatment.

Table 1. Effect of ewe maturity and plane of nutrition from day 1-31 of pregnancy on ewe performance and on plasma hormone and metabolite concentrations

	Mature ewes			Adolescent ewes				Significance		
	H	M	L	H	M	L	s.e.d	Nutrition	Maturity	N x M
DM intake (kg/d)	1.56	0.78	0.47	1.23	0.61	0.37	0.02	***	***	***
Liveweight change (g/d)	154	-38	-163	71	-38	-122	20.5	***	NS	***
BCS change	0.29	-0.02	-0.20	0.52	0.23	-0.11	0.09	***	***	NS
Leptin (ng/ml)	4.6	2.9	2.2	2.0	1.4	1.3	0.17	***	***	***
Insulin (μU/ml)	16.0	12.9	10.2	12.5	9.9	7.7	0.65	***	***	NS
β-hydroxybutyrate (mM)	0.60	0.39	0.33	0.48	0.43	0.36	0.027	***	NS	P=0.06
NEFA (meq/l)	0.12	0.16	0.27	0.15	0.20	0.28	0.018	***	**	NS
Urea (mM)	7.70	6.76	6.14	7.60	6.61	6.24	0.24	***	NS	NS

Conclusions Ewe maturity and plane of nutrition affected the endocrine and metabolic status of ewes in early pregnancy. Differences in DM intake, liveweight change and insulin concentration of ewes reflect the differences in ME allowance, as dictated by the liveweight and age of ewe (AFRC, 1993). Differences in leptin concentration between mature and adolescent ewes are consistent with the difference in their initial BCS. Whilst leptin concentration of mature ewes was consistent with changes in BCS with level of feeding, leptin concentration of adolescent ewes was affected only by high plane feeding. Changes in plasma insulin and leptin concentration during early gestation could therefore be associated with the successful establishment and maintenance of pregnancy.

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Steroid hormones concentration of the postovulatory ovarian follicles of the goose

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Introduction The functional ovary of the mature goose generally contains numerous small white and yellowish follicles, five to nine yellow preovulatory follicles arranged in a follicular hierarchy and several postovulatory follicles. Unlike the mammals, in the birds no corpus luteum is formed following ovulation, but the postovulatory follicles (POF) (Johnson, 1990), which is followed by regressions and resorption via apoptosis. It has been reported that POF are physiologically active during several days and have steroidogenic capacity. Earlier studies in hen showed that 3β-HSD activity was present in the granulosa layer of the postovulatory follicles (Nitta et al., 1993).
Despite strong interest in bird reproductive system there is only little information on the goose ovarian system.
Relatively few data are on the steroid concentration in the theca and granulosa layer of the postovulatory follicles in the hen (Dick et al., 1978) but in the goose have not jet been determined. Therefore the aim of the study was to determine concentration of progesterone, estradiol and androgens in different sizes of the postovulatory follicles.

Materials and Methods The concentrations of steroid hormones (P4 – progesterone, E2 – estradiol and A – androgens) were determined in the follicular wall of the three largest postovulatory ovarian follicles of the goose. The studies were carried out on 12 one-year-old Zatorska geese during the reproductive cycle. Postovulatory follicles (POF1, POF2 and POF3) were isolated from ovaries approximately after egg was layed and before the ovulation. These tissue were homogenized and the concentrations of steroid hormones were measured by RIA methods (Spectria Orion Diagnostic, Finland).
The concentrations of steroid were computed in pg or ng/mg protein and were expressed as means ± SD. Statistical differences were calculated using Student's *t*-test and Duncan's new test.

Results Mean steroid concentration data for the study are given in Table 1. The major findings of the present study were, that in postovulatory follicles of the goose: 1.) The maximum level P_4 was recorded in the largest postovulatory follicles (POF1) then the concentration of P_4 significant decreases in POF2 and next declines throughout the POF3 position. 2.) In all examined follicles the concentration of estradiol (E_2) in the follicular wall was very low and did not vary as follicles changes position from POF1 to POF3. 3.)The greatest of androgens (A)concentration was observed in the POF1 and next level of A was decreased significant with follicular regression.

Table 1 Steroid concentration P_4 (ng/mg protein ± SD), E_2 and A (pg/mg protein ± SD) in the three largest postovulatory follicles (POF1, POF2, POF3) of the goose.

	Progesterone [ng]	**Estradiol [pg]**	**Androgens [pg]**
	Granulosa + Theca layer	Granulosa + Theca layer	Granulosa + Theca layer
POF1	3.61 ± 0.39^a	3.02 ± 0.32^a	8.79 ± 0.42^a
POF2	0.47 ± 0.08^b	3.35 ± 0.29^a	7.02 ± 0.35^b
POF3	bs	3.47 ± 0.27^a	6.58 ± 0.38^b

a, b - significant $p \leq 0,05$
bs – below sensitivity

Conclusions It was concluded that, the postovulatory follicles of the goose, which are not homologous with the mammalian corpus luteum, are an active endocrine tissue. Follicular wall of the postovulatory follicles can synthesise large amounts of progesterone and lesser amounts of androgens and estradiol. Additionally, this study also suggests that the steroidogenic potential of the follicular cells of the postovulatory follicles was markedly reduced during the process of follicular regression.

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Two steroidogenic pathways present in the granulosa layer of the preovulatory follicles of the goose

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Introduction The follicular wall of the ovarian follicles play very important roles for the development of oocyte and ovulation. The major function of this tissue is the biosynthesis of steroids. One of the key enzyme of the steroidogenesis is 3β-hydroksysteroid dehydrogenase (3β-HSD) which converting dehydroepiandrosterone to androstenedione in the Δ^5-3β-hydroksysteroid pathway and pregnenolone to progesterone in the Δ^4-3-ketosteroid pathway. Lee and Bahr (1994) suggested that both Δ^5 and Δ^4 pathway are functional in ovarian follicles. Recently Lee et all (1998) reported that theca layer preferentially metabolises steroids via the Δ^5 pathways regardless of the maturational stage of the follicles, while the granulosa layer of preovulatory follicles metabolises steroids via the Δ^4 pathways. In white follicles the granulosa layer is steroidogenically inactive (Tilly et al., 1991). The changes of 3β-HSD activity in the follicles of the chiken ovary during follicular development are well known (Tilly et al., 1991). However the activity of 3β-HSD in granulosa layer of the yellow preovulatory ovarian follicles of the goose has not yet been determined. Therefore the aim of this study was to determine two steroidogenic pathways present in the isolated granulosa layer of the preovulatory follicles of the goose, by examined enzymatic activity of 3β-HSD using P_5 and DEHA as a substrate.

Materials and Methods The experiment was performed on the 8 one-year-old Zatorska geese. The three largest preovolatory follicles (F1, F2 and F3) which had entered the hierarchy were isolated from ovaries approximately after egg was layed and before the ovulation and granulosa layer were isolated according to Gilbert et all (1977). The enzymatic activity of 3β-HSD in the granulosa layer has been shown using histochemical assay using dehydroepiandrosterone (DHEA) or pregnenolone (P_5) as a substrate. The intensity of the histochemical reaction in the granulosa layer was estimated by measuring the optical density (gray scale with pixel values: from 0-white to 255-black) using the PC-IMAGE system (Foster Findlay Associates Ltd., UK). Date were expressed as mean ± SE. Statistical differences were tested using analysis of variance.

Results The changes of the activity of 3β-HSD in the granulosa layer of the preovulatory follicles is presented in the table 1 and figure 1. The obtained results indicate that: 1.) Using pregnenolone as a substrate the lowest intensive staining was observed in the granulosa layer of the F3 ovarian follicles, next activity of 3β-HSD significant increased as follicles matured. 2.) In contrast, using DHEA as a substrate, the maximum level of 3β-HSD was recorded in the second preovulatory follicles F2 then the enzymatic activity significant decreased as follicles matured (from F2 to F1). In all examined follicles level of 3β-HSD activity was significantly greater when P_5 was using as a substrate.

Table 1 The activity of 3β-HSD in the preovulatory follicles of the goose.

	Pregnenolone	DHEA
F3	145.7 ± 10.8^a	27.7 ± 3.4^d
F2	167.9 ± 9.7^b	38.6 ± 4.9^e
F1	192.1 ± 10.1^c	21.9 ± 3.2^d

a, b,c,d,e – significant at $p \leq 0.05$

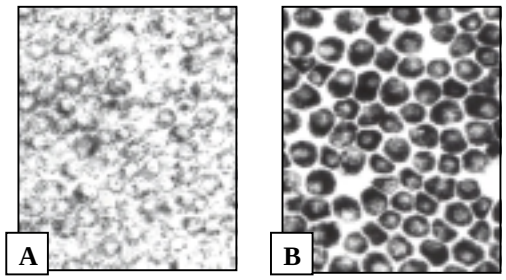

Figure 1 Histochemical demonstration of 3β-HSD reaction in isolated granulosa layer of the largest preovulatory follicles (F1): **A** – with DHEA; **B** – with P_5

Conclusions The results of this reaserch show that both Δ^5 and Δ^4 pathways are functional in the granulosa layer of the three largest preovulatory follicles of the goose. However, in all examined stages of ovarian follicles the activity of 3β-HSD in the granulosa cells is associated with abatament of steroidogenesis via the Δ^5 pathway for the benefit via the Δ^4 pathway.

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Testicular growth and its relationship to body weight of Awassi, Redkaraman and their crossbred ram lambs

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Introduction Rate of testis growth was found to be more rapid in ram lambs of a breed with high prolificacy such as the Finnish Landrace than in a non- prolific breed such as the Scottish Blackface (Land and Carr, 1975). Also, Louda et al. (1981), after observing testis growth, and small but consistent differences in the development of sexual activity and of sperm production, suggested that young rams of prolific breeds (Romanov and Finnish Landrace) may differ in their potential reproductive performance, though slightly. Crossbreeding, primarily a breeding system for commercial production is to take advantage, as far as possible, of good qualities of two or more breeds of distinctly different types (Rice et al.1957). Thus, the present study was conducted to evaluate breeds and reciprocal crossbreeding effects on development of two testicular parameters and body growth in growing Awassi, Redkaraman purebred and their reciprocal crossbred ram lambs.

Material and methods Measurements were performed on a total of 33 Awassi (A) (n=10), Redkaraman (R) (n=10), Awassi x Redkaraman (A x R) (n=7) and Redkaraman x Awassi (R x A) (n=6) ram lambs. The animals were weaned at 90 days of age and grazed on natural pastures. After grazing lambs were offered 1.5 kg/head/day grass hay and 150 g/head/day barley. No hormonal growth stimulant or any other additives were administrated. Assessments were made on rams over a period of 12 months (beginning in Feb) from the time that they were born. Measurements of body weight (BW), scrotal circumference (SC) and testicular volume (TV) were taken monthly. The statistical analysis was conducted using the GLM procedure of MINITAB. The inflection point to determine the age at puberty based on SC values was estimated by using Tanaka nonlinear growth model. The Tanaka is a four-parameter indeterminate growth model having an initial period of growth and a period of exponential growth followed by an indefinite period of slow growth, which is reported as the best fitted growth model to SC data in these breeds by Bilgin et al. (2003).

Result Means and standard errors of body weight, testicular volume and scrotal circumference are shown in Table 1. Redkaraman lambs had heavier ($p<0.05$) birth weight than A and R x A. However, at weaning R x A had similar body weights with R lambs. Body weight was lowest in A ram lambs than the other three breeds throughout study. There was no difference either SC or TV among breeds. Besides, crossbreed lambs had heavier TV at 1 year of age. The age at beginning of pubertal period determined by inflection point in SC growth was found earlier in Redkaraman x Awassi (119.4 d) lambs, followed by Awassi x Redkaraman (139.4 d), Redkaraman (139.7 d) and Awassi (151.9 d) lambs.

Table 1 Least squares means and standard errors for body weight, scrotal circumferences and testicular volume by breed and age

	Breed			
Age	Awassi (A)	Redkaraman(R)	A X R	R X A
	Body Weight (kg)			
Birth	4.2 ± 0.28^{ac}	5.6 ± 0.31^{b}	5.0 ± 0.35^{bc}	4.2 ± 0.38^{ac}
Weaning	16.8 ± 1.15^{a}	22.3 ± 1.28^{b}	20.2 ± 1.45^{ab}	19.1 ± 1.56^{ab}
180 days	27.8 ± 1.50^{a}	34.7 ± 1.66^{b}	34.7 ± 1.88^{b}	31.4 ± 2.03^{ab}
270 days	28.3 ± 1.71	34.8 ± 1.89	35.3 ± 2.14	33.1 ± 2.31
360 days	37.9 ± 1.82	44.5 ± 2.01	42.8 ± 2.28	41.5 ± 2.46
	Scrotal Circumference (cm)			
Birth	8.4 ± 0.21	8.3 ± 0.21	8.5 ± 0.25	8.2 ± 0.28
Weaning	10.8 ± 0.78	10.8 ± 0.78	12.2 ± 0.93	11.6 ± 1.00
180 days	18.9 ± 1.36	20.8 ± 1.36	22.3 ± 1.63	19.9 ± 1.76
270 days	20.4 ± 1.20^{a}	22.4 ± 1.20^{ab}	24.9 ± 1.44^{b}	23.2 ± 1.55^{ab}
360 days	26.2 ± 0.83	26.0 ± 0.83	26.1 ± 0.99	25.9 ± 1.07
	Testicular Volume (ml)			
Birth	2.0 ± 0.22	1.8 ± 0.22	1.9 ± 0.26	2.0 ± 0.28
Weaning	7.9 ± 1.06	5.5 ± 1.06	5.7 ± 1.27	6.6 ± 1.37
180 days	17.7 ± 2.40	21.3 ± 2.40	23.8 ± 2.86	17.9 ± 3.09
270 days	24.0 ± 3.17	32.1 ± 3.17	33.6 ± 3.78	34.1 ± 4.09
360 days	39.8 ± 3.39	42.4 ± 3.39	44.7 ± 4.05	44.7 ± 4.37

^{a,b,c,}: Means within row, by category, comparisons not followed by the same letter are significantly different ($P<0.05$)

Conclusion The results of this study showed that puberty of Awassi lambs was improved by crossing with Redkaraman. Early and rapid pubertal development as indicated by increase in body weight in cross breeds can be obtained by cross breeding efficiently.

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Effect of various final concentrations of glycerol in Tris and milk diluents on post-thawing survival rates of Baluchi ram spermatozoa

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Introduction Glycerol is the most commonly used protective substance in diluents for freezing ram semen (Salamon and Maxwell, 2000). Colas (1975) examined two concentrations of 2 and 4% glycerol for freezing ram semen and recommended an optimal level of 4% glycerol, although it may be slightly toxic to spermatozoa. The optimum concentration of glycerol for freezing ram semen is also influenced by type of diluent (Salamon and Maxwell, 2000). The objective of this study was to investigate the effect of three levels of glycerol 3, 4 and 5% and two types of diluents on motility and live rates of Baluchi ram spermatozoa.

Materials and methods Semen samples were collected from five Baluchi breed of rams using an artificial vagina in sheep breeding station, Abbas Abbad, Mashhad, Iran. Suitable semen samples were pooled and divided into six portions. Each portion was diluted in a ratio of 1:1, semen:diluent, with Tris egg-yolk and semi-skimmed milk containing 3, 4 and 5% glycerol in final concentration. 0.5 ml of straws were filled with diluted semen, cooled to 5˚C, frozen in liquid nitrogen vapor for 7 minutes and then stored in liquid nitrogen (Evans & Maxwell, 1987). Post-thawing live and motility rates of ram spermatozoa of semen samples were assessed and data was corrected using the following formula (Gill, 1987). Y=Arcsin (X/100) ∧0.5, Y=corrected survival percentages and X=survival percentages. The experiment was planned on 3x2 factorial in a completely randomized design to examine three levels of glycerol on two types of diluents of Tris and milk with four replications. Least squares means comparisons were carried out using general linear model, SAS programme at 0.01 probability level.

Results Table 1 shows post-thawing survival rates of Baluchi ram spermatozoa. Before freezing, means of live and motile spermatozoa in Tris egg-yolk and semi-skimmed milk were 92.66; 90.08 and 92.08; 89.75%, respectively.

Table 1. Means (se) of post-thawing live and motility of spermatozoa for each treatment ($p<0.01$)

Factors	Percentage of live spermatozoa	Percentage of motile spermatozoa
Tris egg-yolk diluent	24.17(0.90)a	16.75(0.60)a
Semi-skimmed milk diluent	16.92(0.90)b	11.75(0.60)b
Glycerol concentration (%)		
3	16.63(1.10)b	11.86(0.74)b
4	29.38(1.10)a	19.75(0.74)a
5	15.63(1.10)b	11.13(0.74)b
Diluent*Glycerol concentration(%)		
Tris egg-yolk*Glycerol at 3%	17.00(1.56)bc	12.53(1.05)b
Tris egg-yolk*Glycerol at 4%	37.75(1.56)a	26.25(1.05)a
Tris egg-yolk*Glycerol at 5*	16.75(1.56)bc	11.75(1.05)b
Semi-skimmed milk*Glycerol at 3%	16.25(1.56)bc	11.50(1.05)b
Semi-skimmed milk*Glycerol at 4%	20.00(1.56)b	13.25(1.05)b
Semi-skimmed milk*Glycerol at 5%	14.50(1.56)c	10.50(1.05)b

Effect of type of diluent on post-thawing motility was significant ($p>0.01$). The highest survival rate was obtained for diluted semen in Tris egg-yolk with glycerol in final concentration of 4%. This is in agreement with Colas (1975) and Joshi et al. (1990) who suggested a final concentration of 4% glycerol for 1:1 to 1:4 rates of dilution of ram semen:diluent.

Conclusion The use of Tris egg-yolk diluent with a final glycerol concentration of 4% is recommended for freezing and long term preservation of Baluchi ram semen in Iran.

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The effects of two pure dairy breeds and their reciprocal crosses, and concentrate feeding management, on the performance of beef cattle

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Introduction Currently in Northern Ireland 47% of prime beef production is sourced from the dairy herd, and this proportion is likely to increase post implementation of the Mid Term Review of the Common Agricultural Policy. Whilst Holstein Friesian cows form the main blood line within the dairy herd there is currently major interest in the use of alternative dairy breeds and cross breeding as a way of improving herd fertility and longevity. The present study was undertaken to investigate the effects of two pure dairy breeds and their reciprocal crosses on the performance of finishing beef cattle.

Feed accounts for a large proportion of the costs of finishing beef cattle. Concentrate supplements are fed either as coarse or pelleted rations. Method of ration preparation may affect feed intake and animal performance. Currently in Northern Ireland 55% of beef farmers are part time and consequently feeding concentrates in one feed per day is a practical option on many units to reduce labour requirement. The effects of method of processing concentrate supplement and number of feeds per day on forage intake and animal performance were also evaluated in this study.

Materials and Methods A total of 42 spring born dairy calves, with a mean initial live weight of 321 kg (sd 30.6) were allocated to the study for 241 days. The cattle comprised four genotypes, namely: Holstein (H), Norwegian (N), H x N and N x H. Three concentrate management regimes were examined, namely: pelleted ration offered once daily (P) and coarse ration offered either once (O) or twice (T) daily. Cattle were housed in groups of four or five on slats and offered grass silage *ad libitum* as the sole forage supplemented with 4.5 kg concentrates and 100 g beef mineral and vitamin mixture daily. Silage was harvested from the secondary regrowth of predominantly perennial ryegrass swards and ensiled precision-chopped, treated with a bacterial inoculant. The concentrate consisted of 540, 100, 230, 100 and 30 g/kg fresh weight of rolled barley, maize meal, sugar beet pulp, soyabean and molasses. The coarse ration was mixed in a complete diet wagon whilst the ingredients for the pelleted ration were ground through a 3-mm screen before mixing and pelleting through a 6-mm die. All animals were slaughtered at the end of the study at a mean age of 17.4 months and detailed carcass assessments were undertaken. The study was analysed as a continuous design randomised block experiment using Genstat REML variance components analysis.

Results The silage offered in the present study had pH and concentrations of DM and ammonia (N) of 3.80, 207 g/kg and 81 g/kg N respectively. The effects of breed and concentrate feeding management on animal performance are presented in Table 1. Norwegian cattle tended to have improved (P=0.08) carcass conformation. Otherwise breed and concentrate feeding management did not alter (P>0.05) feed intake, final live weight and carcass weight, kill out proportion, carcass gain or fat class, marbling or food conversion efficiency. There were no breed x concentrate feeding management interactions.

Table 1 The effect of breed and concentrate feeding management on animal performance

	Breed					Concentrate management			
	Hol	Hol x NRF	NRF x Hol	NRF	SED[1]	Pellets	Loose		SED[1]
Number of feeds						One	One	Two	
Feed intake (kg DM/day)									
Silage	4.3	4.4	4.3	4.3	0.09	4.3	4.4	4.4	0.08
Total	8.1	8.2	8.1	8.1	0.09	8.1	8.2	8.2	0.08
Performance									
Final live weight (kg)	536	546	550	545	15.2	545	542	545	12.5
Liveweight gain (kg/d)	0.90	0.94	0.95	0.93	0.063	0.93	0.92	0.93	0.052
Kill out (g/kg)	499	488	487	487	7.9	485	499	486	6.5
Carcass weight (kg)	267	266	268	265	8.9	265	270	265	7.3
Carcass gain (kg/d)	0.51	0.51	0.51	0.50	0.04	0.50	0.52	0.50	0.03
Conformation[2]	1.58	1.66	1.69	1.91	0.138	1.70	1.70	1.73	0.114
Fat class[3]	3.03	3.05	3.01	3.01	0.102	2.94	3.01	3.12	0.084
Marbling	1.97	2.28	2.38	3.17	0.521	2.14	2.43	2.78	0.427
FCE[4]	15.9	16.4	16.3	16.4	1.16	16.3	15.9	16.4	0.95

[1] There were no significant breed (B), concentrate management (CM) or B x CM interactions
[2] EUROP scale: 5, 4, 3, 2, 1 respectively
[3] EU fat classification, where 5 = fat, 1 = lean
[4] kg DM intake/kg carcass gain

Conclusions It is concluded that breed had no effect on animal performance. There was no evidence of heterosis in the reciprocal crosses. There was no benefit in animal performance of pelleting the concentrate supplement prior to feeding, or feeding the supplement in two feeds per day.

The effect of plane of nutrition during the growing and finishing phases, and gender, on the performance of beef cattle

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Introduction Many factors, including plane of nutrition and gender affect the lifetime growth rate of beef cattle, during both the growth and finishing phases. Previous studies have clearly illustrated that a restriction in growth during one period of life results in compensatory growth later in life provided a high plane of nutrition is available during realimentation. It is essential that producers increase final carcass value by achieving cost effective performance at different stages during the life cycle. The aim of the present study was to evaluate the effects of plane of nutrition during the first winter growth and final winter finishing phases on the performance of finishing steers and heifers. Furthermore the effects of *ad libitum* concentrate systems during the finishing phase were also evaluated.

Materials and methods A total of 144 weaned spring-born continental suckled calves, 72 steers and 72 heifers (mean initial live weight of 309 (sd 32.1) and 257 (sd 29.9)) were purchased post weaning in late autumn and allocated to a total of 18 treatments. During the first winter growth phase (106 days), these animals were offered grass silage *ad libitum*, supplemented with either 0 (L), 1.5 (M) or 3.8 (H) kg concentrates/head/day. Subsequently all animals received a common diet which consisted of grazed grass or grass silage supplemented with concentrates. During the final winter finishing phase the cattle were offered grass silage *ad libitum* supplemented with either 3 (L) or 6 (M) kg concentrates/head/day or concentrate *ad libitum* (H) supplemented with 5 kg fresh silage daily. The concentrates offered during the first winter growth phase consisted of 500, 175, 200, 100 and 25 g/kg fresh weight of rolled barley, soyabean, molassed sugar beet pulp, maize meal and vitamins and minerals respectively, whilst the concentrate offered during the final winter finishing phase consisted of 545, 100, 230, 100 and 25 g/kg fresh weight of rolled barley, maize meal, sugar beet pulp, soyabean and molasses. During the final winter finishing phase all animals received 100 g/day of a mineral and vitamin mixture. Cattle were slaughtered in blocks at constant intervals on experiment. Data were analysed as 2 (gender) x 3 (planes of nutrition during the growing phase) x 3 (planes of nutrition during the finishing phase) experiment using Genstat ANOVA.

Results The silages offered in the growing and finishing winter phases had pH and concentrations of DM and ammonia nitrogen (N) of 3.74 and 3.80; 244 and 207 g/kg and 92 and 81 g/kg N respectively. The effects of gender and concentrate feed level during the first winter growing and final winter finishing phases on animal performance are presented in Table 1. Relative to heifers, steers had a higher live weight at the end of the first winter growth phase ($P<0.001$), start and finish of the final winter finishing phase ($P<0.001$), carcass weight ($P<0.001$) and a lower fat classification ($P<0.05$) and tended to have ($P=0.07$) a higher killout proportion. Increasing the plane of nutrition during the first winter growth phase increased liveweight gain during this period and final live weight at slaughter. Relative to the low plane of nutrition the medium and high planes of nutrition during the growth phase increased final live weight, carcass weight, and killout proportion. Increasing the plane of nutrition during the final winter finishing phase increased final live weight, liveweight gain, carcass weight, carcass gain, and fat classification.

Table 1 The effect of gender and plane of nutrition during the winter growing and finishing phases on animal performance

	Gender (G)			Growth phase diet (GPD)			Finishing phase diet (FPD)				Significance[1]		
	Steer	Heifer	SED	Low	Med.	High	Low	Med.	High	SED	G	GPD	FDD
Growth phase													
LWG (kg/d)	0.71	0.65	0.039	0.30^{a}	0.70^{b}	1.04^{c}				0.036	NS	***	
Final LW (kg)	360^{b}	344^{a}	4.2	312^{a}	354^{b}	391^{c}				3.8	***	***	
Finishing phase													
Start wt (kg)	507^{b}	476^{a}	7.2	475^{a}	492^{b}	508^{c}	494	492	490	6.5	***	***	NS
Final wt (kg)	610^{b}	574^{a}	7.2	576^{a}	594^{b}	606^{b}	570^{a}	593^{b}	614^{c}	6.6	***	***	***
LWG (kg/d)	0.94	0.98	0.048	0.96	0.99	0.94	0.73^{a}	0.96^{b}	1.20^{c}	0.043	NS	NS	***
Carcass wt (kg)	331^{b}	307^{a}	4.3	306^{a}	323^{b}	329^{b}	304^{a}	317^{b}	337^{c}	4.0	***	***	***
Carcass gain (kg/d)	0.56	0.55	0.029	0.52^{a}	0.59^{b}	0.55^{ab}	0.39^{a}	0.53^{b}	0.74^{c}	0.027	NS	**	***
KO (g/kg)	542	535	3.8	531^{a}	542^{b}	542^{b}	532^{a}	535^{a}	548^{b}	3.5	0.07	***	***
Conformation[2]	2.90	2.93	0.037	2.92	2.92	2.90	2.90	2.90	2.94	0.034	NS	NS	NS
Fat class[3]	3.35^{a}	3.65^{b}	0.138	3.45	3.41	3.64	3.29^{a}	3.55^{b}	3.66^{b}	0.126	*	NS	*
FCE[4]	17.4	19.4	2.4	18.7	16.4	20.1	24.5	17.6	13.1	2.2	NS	NS	***

[1] There were no significant GPD x FPD or G x GPD x FPD interactions; [2] EUROP scale: 5, 4, 3, 2, 1 respectively; [3] EU fat classification, where 5 = fat, 1 = lean; [4] kg DM intake/kg carcass

Conclusions It is concluded that altering the rate of growth during the growth phase had significant effects on animal performance through to slaughter. The optimum rate of growth during the growth phase for final carcass weight was approximately 0.70 kg/head/day. Furthermore there was no interaction on growth rate between plane of nutrition during the first winter growth phase and final winter finishing phase.

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Intake, growth and feed conversion in weaned suckled heifers finished rapidly on a concentrate-based diet from 9 months old until slaughter at 14-15 months of age

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Introduction Previous work (Hyslop *et al*, 2003) has shown that when finished intensively, 3/4 beef-bred weaned suckled bulls from the UK suckler herd can produce high quality carcasses efficiently with rapid growth rates. Attempting to finish heifers rapidly has traditionally proved difficult since heifers are prone to high carcass fat levels at unacceptable low carcass weights. The objectives of this study were to examine intake, growth and slaughter parameters of weaned suckled heifers from contrasting suckler cow types which had been sired by either a traditional UK beef breed or a continental beef breed and subsequently finished rapidly to slaughter at 14-15 months of age.

Materials and methods A 2 x 2 factorial continuous design experiment was conducted to determine voluntary dry matter intake (DMI), liveweight gain (LWG), feed conversion ratio (FCR) and carcass characteristics in suckled heifers weaned at approximately 8 months of age. Experimental factors were sire breed (S) and dam breed (D). Aberdeen Angus (AA) or Charolais (CH) were used as sire breeds on either Belgian Blue x Holstein (BB) or Simmental x Holstein (SIM) cows as dam breeds. A total of 36 heifers were used (12 pens) with 3 heifers/pen and 3 pen replicates of the AA/BB, AA/SIM, CH/BB and CH/SIM breed groups. Following a 7 week pre-trial period when weaned heifers were gradually introduced to the trial ration, all animals were offered a cereal-based diet *ad libitum* (DM: 866; ME: 10.5; CP 179) from weeks 1-5 of the trial. In an attempt to reduce excessive LWG (week 1-5), a lower energy, NIS based diet (DM: 864; ME: 9.5; CP: 171) was fed from week 6 until slaughter. These diets contained rolled barley, soyabean meal, molasses, minerals and nutritionally improved straw (NIS). DMI was determined for each pen on a weekly basis and individual heifer LWG determined by linear regression on weekly liveweight (LW) measurements. After selection for slaughter (target condition R4L), cold carcass weight (CCW), killing out proportion (KO) along with fatness and conformation scores on a 15-point scale were derived from carcass gradings for each heifer. Analysis of variance for DMI and FCR were carried out on a pen basis and for LWG and carcass data on an individual heifer basis.

Results Average DMI, LWG and FCR (kg DMI/kg LWG) during weeks 1-5 and weeks 6-slaughter; days of age at slaughter (AGE), final LW (FLW), CCW, KO and carcass scores are given in Table 1 along with the F-test significance of the main S and D effects. DMI figures for both concentrate-based diets were generally high across all breed groups contributing to high feed costs. CH sired heifers finished at younger AGE ($P<0.01$), with superior KO proportion ($P<0.001$) and produced heavier carcasses ($P<0.05$) with lower fat scores ($P<0.001$) and better conformation ($P<0.001$) than AA sired heifers. Heifers from BB dams consumed more daily DMI (kg/d) during weeks 6-slaughter ($P<0.05$) and had lower fat scores ($P<0.05$) than heifers from SIM dams. After including £48/heifer slaughter premium and a market price premium of 27.2 p/kg CCW for the AA heifers, Gross Margin figures (£/heifer) were -36, -30, -31 and -56 for the AA/BB, AA/SIM, CH/BB and CH/SIM heifers respectively.

Table 1. Average intake, liveweight gain, feed conversion and slaughter characteristics in weaned suckled heifers.

	Weeks 1-5					Sig[$]		Weeks 6 - slaughter					Sig[$]	
	AA/BB	AA/SIM	CH/BB	CH/SIM	sed	S	D	AA/BB	AA/SIM	CH/BB	CH/SIM	sed	S	D
DMI (kg/d)	9.3	9.0	9.4	8.9	0.69			12.2^{ab}	11.2^{b}	12.3^{a}	11.7^{ab}	0.45		*
(g/kg LW)	26.3	24.3	24.3	23.3	1.44			27.0	24.6	26.6	25.2	1.26		
(g/kg $LW^{0.75}$)	114	107	108	103	6.01			124	115	123	117	5.34		
LWG (kg/d)	1.51	1.67	1.55	1.59	0.169			1.07	1.06	1.08	1.04	0.067		
FCR	6.28	5.48	6.08	5.62	0.757			11.56	10.64	11.36	11.26	0.979		
Slaughter characteristics														
AGE	456^{a}	437^{ab}	418^{b}	434^{ab}	10.0	**								
FLW (kg)	516	506	506	514	10.5									
CCW (kg)	268^{ab}	258^{a}	271^{ab}	276^{b}	6.5	*								
KO (g/kg)	520^{a}	509^{a}	535^{b}	538^{b}	5.6	***								
Fat score	9.7^{a}	9.8^{a}	6.5^{b}	8.8^{a}	0.65	***	*							
Conf score	7.7^{a}	8.0^{ab}	10.7^{c}	9.0^{b}	0.62	***								

Values not sharing common superscripts differ significantly ($P<0.05$)

[$]. SxD F-test was significant for DMI (wk 6-slaughter, AGE, CCW, KO, Fat & Conf scores ($P<0.05$)

Conclusions Whilst rapid finishing of suckler heifers at 14-15 months of age using purchased concentrate diets can produce commercially acceptable carcasses, little opportunity exists for profitable beef production using this system under current costs and price regimes.

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Whole crop wheat for intensively finished beef cattle

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Introduction Since feed accounts for 65-85% of the variable costs of beef production, the use of alternative feeds and high-energy forages that have a lower cost per unit of energy are worthy of investigation. The objective of the experiment was to determine the effect of feeding either fermented whole crop (FWC), Head-cut or Low-cut processed urea treated whole crop wheat (Alkalage) in comparison to *ad libitum* cereals/protein on the performance of intensively finished continental cross beef cattle.

Materials and methods Fifty-four Limousin cross Limousin/Friesian steers with a mean live weight of 268kg were allocated by live weight to the following dietary treatments in a randomised block design. C: A*d lib* 130g crude protein/kg concentrates (850g/kg rolled barley, 80g/kg soya-bean meal, 50g/kg molasses, 20g/kg minerals) plus *ad lib* barley straw. FWC2: *Ad lib* FWC (DM 450 g/kg: 93 g CP/kg DM, 410 g NDF/kg DM, 336 g starch/kg DM) plus 2.0kg of 200g CP/kg concentrates (670g/kg rolled barley, 140g/kg rapeseed meal, 140g/kg soya-bean meal, 50g/kg molasses) plus 100g minerals per head per day. FWC4: *Ad lib* FWC plus 4.0kg of 200g CP/kg concentrates plus 100g minerals. HC: A*d lib* Head-cut (HC) Alkalage (DM 833 g/kg: 156 g CP/kg DM, 423 g NDF/kg DM, 465 g starch/kg DM) plus 100g minerals. HC + L: A*d lib* HC Alkalage plus 500g Lactofeed 70 (a blend of 800g/kg Whey Permeate and 200g/kg Hi-Pro soya-bean meal, Volac International Ltd.) plus 100g minerals. LC + L: A*d lib* Low-cut (LC) Alkalage (DM 781 g/kg: 167 g CP/kg DM, 557 g NDF/kg DM, 356 g starch/kg DM) plus 500g Lactofeed 70 plus 100g minerals. The whole crop was made from the winter wheat variety Consort with a standing height of 75cm. It was cut to leave a stubble height of 30cm with the FWC and LC Alkalage and at 50cm with HC Alkalage. The Alkalage was cut at growth stage 92 and the grain was 'combine fit' It was combined with a harvester fitted with a grain processor and ensiled with 50kg/t DM Home 'N' Dry (a mixture of urea and urease, Volac International Ltd.). The Fermented whole crop was combined at growth stage 83, the early dough stage of grain development, and treated with 4 litres/tonne of Biotal Whole Crop Gold. The data was analysed using ANOVA

Results There were a number of significant differences between the treatment groups for slaughter weight, days to slaughter and daily live weight gain (DLWG), which are shown in table 2. Feed intakes are shown in table 1 with feed costs per kg live weight gain, which were calculated based on the feed prices prevailing at the time of the trial.

Table 1 Feed Intakes (kg/head) and costs

	C	FWC2	FWC4	HC	HC+L	LC+L
130g/kg Cereal mix	1399					66
Straw	170					
200g/kg Cereal Mix		403	763			
FWC		2188	1727			
Head-cut Alkalage				1634	1690	
Low-cut Alkalage						1383
Lactofeed					95	104.5
Minerals		20.2	19.1	19.4	19.0	20.9
Total intake (kg DM)	1329	1348	1445	1380	1515	1253
FCR (kg DM feed/kg gain)	5.51	5.90	5.86	5.79	5.84	5.76
Feed costs (p/kg LWG)	53.9	40.4	47.1	38.2	46.2	45.8

Table 2 Animal performance

	C	FWC2	FWC4	HC	HC+L	LC+L	s.e.d	signif
Start weight (kg)	264.2	265.7	266.7	268.0	265.6	266.1	19.65	ns
Slaughter weight (kg)	505.3^{abc}	493.7^{bc}	512.5^{ab}	516.5^{ab}	525.0^{a}	482.9^{c}	13.94.	*
Days to slaughter	170^{b}	201.6^{a}	191.7^{a}	193.6^{a}	190.1^{a}	209.1^{a}	7.33	*
DLWG (kg)	1.419^{a}	1.124^{cd}	1.289^{be}	1.232^{ce}	1.370^{ab}	1.036^{d}	0.0671	*
Carcase weight (kg)	278.5	268.1	278.4	279.4	285.3	262.2	8.06	<0.074
Killing out %	55.13	54.33	54.04	54.11	54.38	54.32	0.006	ns
Conformation*	4.38	4.33	4.22	4.22	4.22	4.00	0.210	ns
Fat classification*	4.11	4.44	4.22	4.22	4.12	4.43	0.242	ns

Within row, means with the same superscripts are not significantly different ($p>0.05$)
ns = not significant, * = $p<0.05$
* EUROP carcase classification: Conformation: P+=1 and E=7. Fat class: 1=7 and 5H=1.

Conclusions Overall animal performance was comparable to results achieved by top third recorded commercial beef producers winter finishing suckled calves recorded by Signet/MLC. Whole crop would appear to offer beef producers the opportunity to achieve high levels of animal performance and reduce feed costs per kg live weight gain.

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Effect of high versus low levels of milk replacer on the performance of dairy-bred beef calves

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Introduction Artificial rearing is a common practice for rearing calves from the dairy herd destined for beef production. Calves fed increased amounts of milk replacer in early life have higher live weight gains than those on lower levels of milk and are subsequently heavier at weaning. After a period of nutritional restriction beef animals can exhibit compensatory growth. However it has been suggested that growth restriction in early life can result in reduced levels of compensation (Ryan, 1990). The objective of this study was to determine the effect of increasing the daily allowance of milk replacer offered on a restricted basis to Continental x Holstein beef calves during the first 6 weeks on compensatory growth from weaning to 11 weeks.

Materials and methods Thirty-two Belgian Blue x Holstein bull and heifer calves were assigned in a randomised block designed experiment to either a low (L) or high (H) level of milk replacer feeding rate. Calves were fed a whey based milk replacer (DM 976 g/kg, 232g crude protein/kg, 182 g/kg Ether Extract [Blossom Easy Mix - Volac International Ltd.]). For treatment L, milk replacer was reconstituted at 100g per 900ml of water at 40^{o}C and fed at 4.5 litres per day, in two equal feeds. From 5 weeks old the milk replacer was fed at 2.25 litres per day to weaning at 6 weeks old. For calves on treatment H, the milk replacer was reconstituted at 125g per 875ml of water at 40^{o}C fed from 3 days of age at 6 litres per day in two equal feeds. From 5 weeks old the milk replacer was fed at 3 litres per day to weaning at 6 weeks old. From day 4 the calves received *ad libitum* concentrates (DM 860 g/kg; 12.0 MJ ME/kg DM; 182g crude protein/kg DM) plus water. The calves started the trial at 3 days of age and were individually penned on straw. They were moved into group pens at 6 weeks old. The data was analysed by ANOVA with calves blocked according to sex.

Results The calves fed the high rate of milk replacer had significantly higher weaning weights and daily live weight gains (DLWG) from birth to 3 weeks and birth to weaning (see tables 1 &2). There were no significant differences in feed intakes (see table 3) or calf performance from weaning to 11 weeks. There were no differences in the health or condition of the calves with 2 calves from each treatment being treated for scour.

Table 1 Effect of High versus Low milk replacer feeding rate on live weight (kg)

Milk feeding rate	Low	High	s.e.d	Significance
Birth weight	46.3	46.9	2.09	NS
3 week weight	52.5	56.5	2.04	NS
6 week weaning weight	60.6	66.2	2.45	*
11 week weight	91.5	97.9	4.08	NS

NS = not significant, *P<0.05

Table 2 Effect of High versus Low milk replacer feeding rate on DLWG (kg)

Milk feeding rate	Low	High	s.e.d	Significance
Birth - 3 week	0.297	0.431	0.0473	*
3 - 6 weeks (weaning)	0.384	0.487	0.0656	NS
6 - 11 weeks	0.883	0.906	0.0651	NS
Birth to weaning	0.341	0.459	0.0390	*
Birth - 11 weeks	0.587	0.662	0.0450	NS

Table 3 Concentrate feed intakes (kg/head) and Feed Conversion Ratio

Milk feeding rate	Low	High	s.e.d	Significance
Intake Birth – weaning	16.9	15.2	2.34	NS
Intake Weaning – 11 weeks	84.67	83.05		
Total Intake Birth – 11 weeks	101.3	98.3		
Feed Conversion Ratio	2.70	2.55	0.202	NS

Milk Replacer intakes were 16kg and 26.6kg litres per calf for the L and H feeding rates respectively. Based on the prices prevailing at the time of the study with milk replacer @£1170/t and concentrates @£240/t, the total feed costs per calf to 11 weeks were £43.06 and £54.74 for the L and H treatments respectively with the latter having gained an extra 5.8kg live weight to 11 weeks.

Conclusions Feeding calves a high rate of milk replacer had a significant effect on performance to weaning. It is evident that compensatory growth did not occur after weaning with the calves fed the low level of milk replacer

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Effect of various levels of imbalance between energy and nitrogen supplies on nitrogen metabolism in growing double-muscled Belgian Blue bulls

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Introduction Recent efforts to enhance the productive performance of ruminants through improved synchronisation of energy and N supplies in the rumen did not result in detectable benefits for the animals (Richardson et al., 2003). As suggested by Lapierre and Lobley (2001), the movements of N across the gut play a major role in regulating the amount of ruminally available N and provide an overall plasticity to allow rapid response to any changes in metabolic status. The objective of the present study was to examine the effects of various levels of imbalance between energy and N release in the rumen on the double-muscled Belgian Blue (dm-BB) digestion and N metabolism.

Material and methods Six dm-BB bulls initially weighing 299 ± 31 kg and fitted with a ruminal cannula were used in the study. The bulls received the same diet, at an intake level of 80 g DM/kg$^{.75}$, according to three different feeding patterns, so that three different levels of imbalance between energy and nitrogen supplies for the rumen microbes were created. The diet was made up of 91% of concentrates and 9% of wheat straw and supplied 99 g of intestinal digestible proteins (DVE) and 7.8 MJ of net energy for fattening per kilogram of DMI according to the Dutch system. The feedstuffs were shifted between the 0830 and 2030 feeding to provide either a balance (L0) or an imbalance (L1 and L2) supply of OM and N to the rumen. The level of imbalance was measured by the variation of the ruminal degradable N (RDN) and fermentable OM (FOM) ratio between the two meals of a day, while on a daily basis, this ratio was closed to 23 g/kg. For the 0830 feeding, the RDN:FOM ratios amounted to 23.0, 16.8 and 10.5 g/kg, respectively for L0, L1 and L2, and for the 2030 feeding, to 23.0, 29.2 and 35.5 g/kg. The levels of imbalance reached thus 0, 6.2 and 12.5 g RDN/kg FOM, respectively for L0, L1 and L2. The bulls were allocated to three treatment periods in two juxtaposed 3 × 3 Latin squares. Rumen fermentation was monitored by pH and ammonia concentration. Faecal output was measured using chromic oxide as an indigestible flow marker and the total urine collection was realised with an adaptation of the apparatus of Veenhuizen et al. (1984). Urine was analysed for N, and feed and faeces for N, OM and NDF.

Results Unlike pH, the ruminal ammonia concentration was highly influenced by the nature of the feed ingredients ingested and attested the existence of periods of excess and deficiency in N supply. The period of time that rumen ammonia concentration was below 5 mg/dl depended on the meal ingested and amounted to 9h, 10h and 12h over the 12h after the 0830 feeding, respectively for L0, L1 and L2, and to 9h, 7h and 5h over the 12h after the 2030 feeding. OM, NDF and N digestibility were not significantly affected by the feeding pattern (Table 1). The N ingested and the N excreted in faeces were similar among the three treatments and reached on average 143 and 47.6 g/d. Contrariwise, bulls fed with the higher level of imbalance (L2) had a higher urinary N output (p = 0.02) than bulls fed without imbalance (L0). The N retention were not affected by the level of imbalance between N and energy supplies for the ruminal microbes. But the portion of the N digested retained by the animals was significantly reduced only for the bulls fed the diet with the higher level of imbalance (L2) and was 9.6 % lower in comparison with L0.

Table 1 Diet digestibility and N balance of bulls fed the same diet with different levels of imbalance between energy and N supplies for ruminal microbes.

	Level of imbalance			SEM	p	Dunnett's t Test	
	L0	L1	L2			L0 *vs* L1	L0 *vs* L2
OM digestibility (%)	74.4	74.7	74.6	0.3	0.731	NS	NS
NDF digestibility (%)	69.6	70.3	68.9	0.6	0.297	NS	NS
N digestibility (%)	66.4	66.6	67.3	0.6	0.642	NS	NS
N Intake (g/d)	142.9	142.9	143.1	1.4	0.989	NS	NS
N Faecal (g/d)	48.0	47.9	46.8	0.9	0.626	NS	NS
N Urinary (g/d)	46.4	47.6	51.7	1.3	0.047	NS	0.020
N Retained :							
- g/d	48.5	47.3	44.7	1.3	0.157	NS	NS
- % N ingested	34.0	33.3	31.1	0.7	0.056	NS	NS
- % N digested	51.1	49.8	46.2	1.0	0.018	NS	0.007

Conclusions These results indicated that feeding a diet with an imbalance between energy and N release in the rumen did not greatly influence the digestibility and the N retention of dm-BB bulls if the daily RDN:FOM ratio's variation did not exceed 6.2 g RDN/kg FOM. Conversely, when the level of imbalance increased to 12.5 g RDN/kg FOM, the smoothing capacity of growing bulls seemed overtaken as urinary N output increased and the use of the N digested by the animals decreased.

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An evaluation of a yeast culture-based feed additive on the performance of Holstein-Friesian bulls offered a cereal-based diet

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Introduction The number of Holstein bulls finished on high concentrate diets in Northern Ireland has increased in recent years. This has reflected the ready availability at low cost of calves from the dairy herd and the availability of bull beef premiums, as well as the reduction in cereal prices realised over the last few years. The addition of yeast cultures to ruminant rations may have beneficial effects on feed efficiency and growth rate and are therefore of considerable interest in view of the current low profitability in the beef industry. The objective of the present study was to evaluate the potential of a yeast culture-based feed additive to improve the performance of Holstein-Friesian bulls when finished on a high-concentrate diet.

Materials and methods Fifty-four Holstein-Friesian bulls, mean initial age 171 (sd 8.2) days and live weight 230 (sd 23.4) kg, were blocked according to liveweight and allocated to two dietary treatments on a random basis. The treatments were: (1) control diet comprising *ad libitum* concentrates, or (2), the control diet in which a yeast culture based additive (containing viable cells of *Saccharomyces cerevisiae* Sc. 47 at a concentration of 10^{10}CFU/g) had been incorporated at the manufacturers recommended rate (500 g/t). All animals were also offered a restricted quantity of barley straw (0.5 kg/head/d). Animals in each treatment group were housed in groups of four animals on slatted pens and slaughtered at distinct slaughter weights ranging from 400 to 550 kg liveweight. Concentrate and total dry matter (DM) intakes for each pen group of four animals were recorded daily throughout the trial. The composition of the concentrate was changed when animals reached 350 kg live weight and contained the following ingredients (g/kg) : maize meal 100 and 100, sugar beet pulp 200 and 200, vitamin/mineral premix 25 and 25, barley 500 and 555, and soyabean meal 175 and 120 for concentrates offered pre and post 350 kg liveweight respectively. All bulls were weighed on two consecutive days initially and again prior to slaughter, and at intervals of four-weeks throughout the study. A range of carcass measurements was recorded for all animals. Data on food intake and carcass parameters were analysed using the REML technique in Genstat 5 (release 4.1, Rothamsted, England), with covariates as appropriate, to compare the two dietary treatments. Carcass weight at the beginning of the trial was estimated by assuming a dressing proportion of 0.47 (Patterson *et al*., 1995).

Results The mean chemical composition of the concentrate offered pre and post 350 kg liveweight was (respectively) : DM 852 and 856 g/kg, crude protein 191 and 149, acid detergent fibre 81 and 80, neutral detergent fibre 184 and 181 and ash 75 and 65 g/kg DM. Data on food intake and animal performance are presented in Table 1. Addition of the yeast culture increased concentrate ($P<0.001$) and total DM intakes ($P<0.01$). However, the addition of yeast culture had no significant effect ($P>0.05$) on any of the production parameters evaluated, including live weight gain, carcass weight, carcass gain, feed conversion efficiency, killing out proportion, carcass conformation and fat class, and marbling score.

Table 1 Data on food intake, animal performance and carcass parameters

	Dietary treatment		SED	Significance
	Control	Additive		
Food intake data (kg DM/d)				
Concentrate	6.65	6.95	0.078	***
Total	7.18	7.42	0.078	**
Animal performance and carcass data				
Days on trial	201	198	5.2	NS
Final liveweight (kg)	480.0	480.0	0.00	NS
Live weight gain (kg/d)	1.26	1.29	0.035	NS
Carcass weight (kg)	252.5	254.7	1.97	NS
Carcass gain (kg/d)	0.73	0.76	0.023	NS
FCE carcass [1]	10.01	9.85	0.315	NS
Kill out (carcass weight/liveweight)	0.53	0.53	0.004	NS
Conformation [2]	3.41	3.66	0.352	NS
Fat grade [3]	4.34	4.42	0.226	NS
Marble score [4]	1.54	1.66	0.117	NS

[1] feed conversion efficiency (kg total DM/kg live weight or carcass gain); [2] 15 point scale: 1 = worst; 15 = best; [3] 10 point scale: 1 = leanest; 10 = fattest; [4] 8 point scale: 1 = low marbling; 8 = high marbling

Conclusions The results indicate that the addition of the yeast culture-based feed additive to the diet had no significant effect on animal performance or any of the carcass parameters assessed.

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Effect of diet and breed on skatole deposition in cattle slaughtered at 19 or 24 months

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Introduction Skatole is formed as a result of bacterial degradation of tryptophan in the rumen of cattle and sheep, and the hindgut of pigs. It accumulates in fat where it is an important component of boar taint in pigs (Claus *et al*, 1994), and with branched chain fatty acids, has been implicated as a contributor to the strong flavour characteristic of sheepmeat (Young *et al*, 1997). This study examines the role of breed, diet and age on skatole deposition in the fat and perception of beef flavour.

Materials and methods 64 steers, 32 each of Aberdeen Angus (AA) and Holstein-Friesian (HF) were raised from 6 months on either perennial ryegrass-silage (containing 0.15 sugar beet pulp) or concentrate (0.6 barley, 0.2 sugar beet pulp, 0.125 full-fat soya) so that both groups grew at a similar rate, and were slaughtered at 19 or 24 months. An additional 8 animals of each breed were reared on grass-silage to 14 months, grazed on pasture and slaughtered at 19 months. Skatole levels were measured as described in Annor-Frempong *et al* (1997) and sensory analysis as in Vatansever *et al* (2000)
Analysis of variance was performed using the SPSS statistical package version 11.5.

Results There was no difference in skatole concentration between ages or breeds (Table 1). Skatole levels were significantly higher in concentrate-fed steers than those fed silage at 24 months (P<0.001). At 19 months, pasture-fed steers had 9-fold higher levels of skatole than those fed either silage or concentrates (P<0.001).

Table 1 Effect of diet and breed on skatole deposition in subcutaneous fat (ng /g tissue)

	Concentrate		Grass Silage		Pasture			
Age	AA	HF	AA	HF	AA	HF	sed	
19mths	5.16[a]	5.13[a]	1.58[a]	1.95[a]	50.27[b]	40.74[b]	5.323	***
24mths	4.15[b]	4.09[b]	2.30[a]	2.81[a]	-	-	0.509	***

Means within rows with different superscripts differ significantly, P<0.001 ***

Sensory analysis of grilled loin steaks by a trained taste panel showed that both pasture and silage-fed cattle had higher scores for beef flavour intensity compared with concentrate-fed cattle (P<0.01), and lower abnormal flavour intensity scores (P<0.001). Overall liking scores were higher in pasture and silage-fed than the concentrate-fed cattle (P<0.05). At 24 months the same trend was present but the differences were not significant.

Table 2 Influence of diet on sensory analysis of grilled loin steaks from 19month cattle

	Concentrate	Grass Silage	Pasture	sed	
Beef flavour	23.3[a]	27.6[b]	26.4[b]	1.35	***
Abnormal flavour	19.5[b]	11.5[a]	13.0[a]	1.42	***
Overall liking	16.3[a]	20.1[b]	20.2[b]	1.51	*

Means within rows with different superscripts differ significantly, P<0.001 ***, P<0.05 *

Conclusions These results show that skatole levels are greatly influenced by diet in beef. High levels in pasture-fed cattle were associated with high beef flavour scores, so it appears that skatole is not a negative contributor to flavour as it is in pork.

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The effects of Clinoptilolite on ammonia toxicity and performance of Holstein calves

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Introduction Grazing cattle often require supplemental nutrients, especially at times when forages are dormant. To meet this requirement, producers have several options. They may supplement proteins or non-protein N (such as urea) or a combination. Urea is rapidly hydrolyzed to ammonia; consumption of high levels of urea could lead to ruminal ammonia accumulation, inefficient use of N by the animal and animal ammonia toxicity. Moreover, environment pollution is another problem when inefficient use of N occurs. Natural Zeolite is an Aluminosilicate with Cation Exchange and adsorption properties (Tomlinson, 1998). We hypothesized that Natural Zeolite can adsorb ammonia when its concentration in the rumen is high, and return it when ammonia concentration is low. Therefore, this effect can reduce ammonia toxicity and enhance calves performance and carcass traits. This study was conducted to determine the effect of natural zeolite on ammonia toxicity, carcass traits, performance and nutrient digestibility in finishing Holstein calves.

Materials and Methods In a Complete Randomized Design, 24 Holstein male calves (275 Kg initial BW) were assigned randomly to one of three dietary treatments including group 1(control): without urea and zeolite; group 2) 20g/kg DM urea; group 3) 20 g/kg DM urea + 40 g/kg DM zeolite that were similar in Net Energy and Metabolizable Protein content. Blood samples were collected on d 60 and 120 then analyzed for plasma urea nitrogen. Dry Matter, Crude Protein, crude Fat and NDF digestibility were determined in vivo. Calves were slaughtered after 120 days trial. Carcass traits and ammonia toxicity signs in meat, kidney and liver were investigated. Data were analyzed according to the GLM procedure of the SAS (SAS, 1996).

Results and Discussion Plasma urea nitrogen was influenced by diets (Table 1), with the highest mean in-group 2 (14.73mg/dl) and lowest one in %0 urea (11.73mg/dl). In-group 3, Natural Zeolite supplementation decreases plasma urea nitrogen and ammonia toxicity signs in carcasses, livers and kidneys. Average daily gain was differ significantly ($p<0.05$). The highest daily gain was for group 1(1.30Kg/day) and lowest one for group 2(1.21Kg/d). Hot carcass weight and eye muscle diameter were changed among treatments ($p<0.05$). Abdominal fat weight and fat diameter on eye muscle were high in control group (17.81Kg and 15.06 mm, respectively) and low in-group 2 (14.47Kg and 13.20 mm, respectively). Group 3 was between another two groups in all parameters. Protein and fat percentage of 9-10-11 ribs significantly different between treatment ($p<0.05$), with highest protein percentage in group 2 (51.97%) and lowest in control group (48.54%). DM, crude protein, crude fat and NDF digestibility was affected by diets.

Table 1 Mean of some measured parameters

	Treatment				
Parameters	1	2	3	Mean	s.e.m.
Initial BW (Kg)	276.38	274.81	276.13	275.77	13.74
Final BW (Kg)	458.75[a]	449.00[b]	456.18[a]	454.64	6.04
ADG (Kg)	1.30[a]	1.21[b]	1.26[a]	1.25	0.04
DMI (Kg)	7.64[b]	7.59[c]	7.68[a]	7.64	0.03
Feed Conversion Ratio	5.81[c]	6.04[a]	5.93[b]	5.92	0.07
Plasma Urea Nitrogen mg/ml					
d 60	11.73[c]	14.73[a]	12.87[b]	13.11	0.03
d 120	12.03[c]	14.71[a]	13.10[b]	13.28	0.04
NDF digestibility (%)	45.13[b]	46.78	46.22[a]	46.25	1.28

Means in the same column followed by different superscripts differ at $p<0.05$.

Conclusion Natural Zeolite supplementation to diet containing urea not only decrease ammonia toxicity signs in carcass but also increase average daily gain, nutrient digestibility and meat quality.

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Phosphorus kinetics in calves experimentally infected with *Cooperia punctata* evaluated by isotopic dilution technique

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Introduction Parasitic intestinal infections can affect the health of calves inducing symptoms like loss of appetite, diarrhoea, nutritional deficiency, loss of protein, and reduced weight gain. *Cooperia punctata* is the most prevalent parasitic intestinal nematode in Brazil (Lima, 1998) and its site of fixation is the upper part of the small intestine, i.e., duodenum and jejunum (Bailey, 1949) that are also the sites of greatest dietary phosphorus absorption (Schröder *et al*., 1995). Thus, the damage caused by the parasite when it penetrates the intestinal epithelium can interfere with phosphorus metabolism. The objective of this experiment was to evaluate the true phosphorus absorption by calves submitted to an acute infection with *C. punctata* using the ^{32}P isotopic dilution technique.

Materials and methods Ten male three-month-old Holstein calves were used in the study. After weaning, five calves received a single oral dose of 45000 *C. punctata* infective larvae, and five calves remained as non-infected control animals. All calves received a dose of 29.6 MBq/kgLW of ^{32}P via jugular vein. For inorganic phosphorus and radioactivity measure, blood samples were collected after 5 min. and each 24 h during 7 days. Feaces and urine samples were collected each 24 h during 7 days. Blood samples were also collected for total proteins and albumin measures. After this 7 day period calves were killed and tissue samples (liver, kidneys, heart, muscles and bone) were collected for determination of inorganic phosphorus and radioactivity. Intestine samples were collected, fixed in 10% formalin, cut, and stained with hematoxylin-eosin for histopathological evaluation. Samples of intestinal contents were taken and fixed in 10% formalin for estimation of total worm burdens.

Results Phosphorus metabolism and serum proteins data are given in Table 1 and 2, respectively. There were no significant differences ($p > 0.05$) between infected and non-infected groups regarding to phosphorus consumption (Cons), excretion (Excr), endogenous excretion (End) and true absorption (Abs) in gram per day (g/d) or milligrams per kg of metabolic weight (mg/kgMW), as well as biological availability, and serum proteins. Number of worms varied from 7900 to 17500. There were adult parasites localized in the villi close to the crypts and on intestinal lumen, and microcysts resulting from parasites destruction were observed on the intestinal mucosa.

Table 1 Phosphorus comsumption, excretion, endogenous, absorption, and biological availability *

	Treatments		
Parameters	Infected	Non-infect	s.e.m.
Cons (g/d)	12.43	12.43	0.008
Cons (mg/kgMW)	526.00	524.00	24.75
Excr (g/d)	5.46	6.45	0.653
Excr (mg/kgMW)	232.00	159.00	27.13
End (g/d)	2.60	1.80	0.409
End (mg/kgMW	110.00	77.00	18.54
Abs (g/d)	9.51	10.66	0.542
Abs (mg/kgMW)	404.00	452.00	35.19
Biol. availability	76.53	85.54	4.154

*Effects of treatments on all variables were not significant ($p > 0.05$)

Table 2 Serum total proteins and albumin *

	Treatments		
Parameters	Infected	Non-infect	s.e.m.
Total prot (g/dL)	6.56	6.08	12.51
Albumin (g/dL)	3.58	3.54	6.12

*Effects of treatments on all variables were not significant ($p > 0.05$)

Conclusions Acute *C. punctata* infection did not affect parameters of phosphorus metabolism Although results show higher values on P absorption for non-infected group.

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Selenium enriched grass silage and winter barley for growing bulls: feedstuff composition and animal performance

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Introduction Selenium (Se) is a trace element of large importance owing to its implications in many metabolisms both in animals and in humans. Se participates in the antioxidant protection of cells and shows profound effects on health as e.g. cancer protection, antiviral effect, cardiomyopathy prevention,… in men (see review by Lyon et al 2003) and as prevention of metritis, mastitis or myopathies in cattle (Jukola et al, 1996). There are areas -Belgium e.g.- in which the Se content of feedstuff for cattle is rather low. Se is available for plants from the soil. The aim of the present work was to increase the Se content in grass silage and winter barley using Se enriched fertilizers for young growing bulls.

Materials and methods Grass silage and winter barley were produced on plots in which fertilizer enriched in Se was spread in order to provide 3g Se/ha at each grass silage cut and 10 or 15g Se/ha for barley. Fertilizer without Se was used in the control plots. A total of 10 young growing double muscled bulls from the Belgian Blue breed were offered during the winter period a diet based on grass silage and supplemented with barley, soya bean meal and sugar beet pulp. Blood samples were obtained from the jugular vein before the morning meal on the beginning and at the end of the growing period which lasted for 73 days. One way analysis of variance was used to compare the effects of Se inclusion in the fertlizer.

Results Table 1 summarizes the effects of Se addition in the fertilizer on the crops. There were no effects of the level of Se –10 *vs* 15g/ha- on the Se content in the winter barley. Se content was increased 8 fold in the barley and 3 fold in the grass silage (P<0.001). The initial liveweight (ILW) and the average daily gain (ADG) were similar (Table2). The Se content measured as glutathion peroxydase (GPX) was rather low on the beginning of the trial at 29.7 µg/l. It did not change in the control group but was increased 1.6 fold in the group offered Se enriched feeds.

Table 1 Selenium (Se-µg/kg DM) content in winter barley and in grass silage grown either without (C) or with (Se) Se enriched fertilizers

	C	Se	SED	P<F
Wint. barley	27.5	225.0	1.4	0.001
Grass silage	54.2	165.2	17.5	0.001

Table 2 Animal performance and plasma Se contents in young growing bulls offered a diet in which winter barley and grass silage were grown either without (C) or with (Se) Se enriched fertilizers.

	C	Se	SED	P<F
ILW kg	338.0	328.8	40.9	0.828
ADG kg	1.27	1.23	0.15	0.776
DMI kg/d	7.2	7.2	-	-
Se as GPX µg/l				
begin	27.8	31.6	4.8	0.448
end	26.4	42.4	5.0	0.013

Conclusions The use of Se enriched fertilizers largely increased the Se content of feedstuffs as selenoprotein and increased the Se status of cattle offered these feedstuffs. Since Se in plants is available on an organic form, the enrichment by fertilisation along the soil -plant-animal axis appears safer than the use of mineral supplement as Se selenate or Se selenite, the only authorized forms in different countries of the EU. Increased safety is due to more even Se allowances by the main dietary compounds during the winter period and eventually during the grazing period and to lower toxicity risks owing to misdistribution or misdosage of the mineral supplement. Furthermore, Se in selenoproteins enters directly into the metabolic pathways while mineral forms undergo reductive metabolism to yield hydrogen selenide.

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Selenium enriched winter barley for fattening bulls : animal performance and plasma metabolites

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Introduction Selenium (Se) intake in human is rather low in many countries (Combs 2001). Different strategies to increase human selenium intake were summarized recently by Lyons et al (2003). Selenium fertilization of crops and grass based on the Finnish experiment of the early 80 trebled Se intakes and nearly doubled plasma Se concentration within 3 years of programme's initiation. Meat from Se supplemented animals contains Se at a high level so that such a meat contributes to a large extent of Se supply for man. The aim of the present work was to assess the effect of selenium enriched winter barley in fattening bulls with large muscle development.

Materials and methods Two groups of 5 young Belgian Blue double muscled bulls previously offered a growing diet based on grass silage and winter barley grown either without or with Se fertilizers (see previous paper) were fed with a finishing diet containing 500g/kg winter barley without (C) or with Se (Se). The remaining 500g/kg diet was a complementary concentrate made of sugar beet pulp, linseed meal, soya bean meal, molasses, bicarbonate and a mineral mixture. A first group of 3 bulls was slaughtered after 88 days of finishing. The remaining 2 animals of a smaller size were slaughtered after 180 days. Blood samples were taken at regular intervals and on the end of fattening. Surprisingly blood Se concentration, measured by glutathion peroxydase (GPX), increased in both groups. It appeared that the Se increase was due to a high level of Se in the complementary concentrate owing to an unauthorized Se enriched mineral mixture. The mineral mixture was withdrawn for the finishing of the remaining bulls. The data were treated by two ways analysis of variance.

Results In the early slaughtered group, there were no effects of Se enrichment of barley on the performance and meat characteristics. The lack of effects was associated with the undesirable supply of Se. Nevertheless, the Se content was significantly higher in meat of the Se group (588.3 *vs* 455.3 µg/kg DM; $P<0.05$). When Se was supplied only by barley for the bulls of the late slaughtered group, there were tendencies for a less dark meat (higher L*) and a lower oxidative rancidity as indicated by reduced thiobarbituric acid-reacting substances (TBARS) contents.

Table 1: Animal performance, meat characteristics and plasma metabolites in growing fattening bulls offered a fattening diet in which winter barley was grown either without (C) or with (Se) Se enriched fertilizers

	Early slaughter		Late slaughter			P	P
	C	Se	C	Se	SED	Early	Late
Performance							
ILW (kg)	480.2	473.0	375.3	337.0	17.2	NS	NS
ADG (kg/d)	1.468	1.409	1.515	1.516	0.108	NS	NS
FI (kg/d)	8.66	8.66	9.30	9.30	-	-	-
Meat characteristic							
Color L* d7	42.60	42.50	39.42	41.87	1.28	NS	NS
a* d7	17.98	19.47	19.41	19.3	2.00	NS	NS
b* d7	17.78	18.36	18.19	18.21	0.61	NS	NS
Ranc. TBARS (mg/g) d2	0.110	0.114	0.074	0.080	0.030	NS	NS
TBARS (mg/g) d8	0.846	1.034	0.805	0.514	0.264	NS	NS
TBARS (mg/g) d14	1.555	2.372	1.424	1.328	0.767	NS	NS
Se (µg/kg DM)	455.3	588.3	643.0	682.5	49.86	0.05	NS
Plasma Se (µg/l)							
Se GPX begin	26.7	43.7	26.0	40.5	8.1	NS	NS
Se GPX end	55.0	80.1	70.3	90.0	7.4	0.10	NS
Se plasma	74.0	82.0	76.0	73.0	5.2	NS	NS

Conclusion Although considered as first results, the present data indicate that high Se barley produced by Se enriched fertilizer and included at a 500 g/kg in a finishing concentrate improved the Se content in beef meat of double muscled bulls.

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Characterization of transcribed ovine lymphocyte antigen (OLA) class I genes by single strand conformational polymorphism (SSCP) and sequence analysis

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Introduction The Major Histocompatibility Complex (MHC) class I genes encode polymorphic cell surface glycoproteins that initiate cytotoxic immune responses by presenting processed antigenic peptides to $CD8^+$ T cells. Due to their functional role and polymorphic nature, MHC class I genes have been used in disease association and vaccine development studies in many species. A prerequisite for such studies is the availability of animals of defined MHC haplotypes. However, the ovine MHC (OLA) class I genes have been studied largely by serology and very limited information is available at the DNA level (Dietert R., 1996). In this study, we aimed to identify the number of transcribed OLA class I genes in two Blackface rams and to obtain sequence data for exons 2 and 3. These data will be used to establish an allele specific PCR based typing system to genotype a cohort of progeny for each ram. This will enable allocation of alleles to individual haplotypes and inform a breeding strategy for the generation of MHC defined animals for functional and disease association studies.

Materials and Methods RT-PCR products of exons 2 and 3 of OLA class I genes were obtained from cDNA of two rams (1, 2). Amplification was conducted with three primer pairs (A: GGCTACGTGGACGACACG and Ar: CCCTCCAGGTAGTTYCT, B: GCTACGTGGACGACACGC and Br: AGCGCAGGTCCTCGTTC, C: CGGCTACGTGGACGACAC and Cr:ATGGGTCACATGTGYCTTTG) under the following conditions: denaturation for 5 min at 94°C; 30 cycles of 1 min at 94°C, 1 min at 50°C and 1 min at 68°C, and final extension for 7 min at 68°C. Products from all three PCR reactions were cloned in *E. coli* and white colonies were picked and processed for colony PCR with primers B and Br, as described elsewhere (Hawker and Billadello, 1993). A total of 180 colony PCR products from each ram were subjected to Single Strand Conformational Polymorphism (SSCP) analysis, as described by Ainsworth et al. (1991). Up to 5 replicates of clones with different SSCP patterns were sequenced using a 377 ABI PRISM DNA sequencer (Perkin Elmer, USA).

Results Six different transcribed OLA class I sequences were identified for ram 1 and eight for ram 2. The SSCP patterns and the number of clones identified for each sequence are shown in figure 1. Two sequences from each animal were identified in a large number of clones, which may reflect a higher level of transcription of these genes compared to the others (Fig. 1).

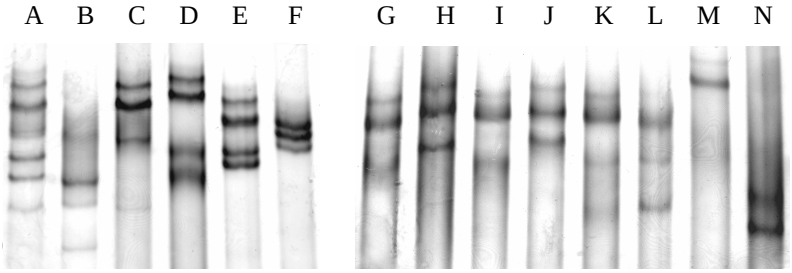

Figure 1: SSCP patterns identified for rams 1 (A to F) and 2 (G to N). Each different sequence folds into a few different conformations, which are unique to the sequence and therefore show a certain band pattern on an acrylamide gel. The number of clones identified with each pattern is shown.

Conclusions Identification of different sequences was based on SSCP analysis of the most polymorphic exons of MHC class I genes (exons 2 and 3) that encode the antigen binding site (ABS). Six (ram 1) and eight (ram 2) distinct sequences formed different SSCP patterns; none of these sequences has been described previously. SSCP analysis of the sequence encoding the ABS of OLA class I genes has therefore proved a useful tool for identifying new alleles. The number of sequences obtained indicates that at least three OLA class I loci are transcribed by ram 1 and at least four by ram 2; studies to date have indicated the existence of only two or three OLA class I loci (reviewed in Dietert R., 1996). Since the primer pairs used were designed in well-conserved areas, the number of clones found (Fig. 1) for each sequence amplified by these primers should roughly reflect the abundance of the corresponding mRNA. Therefore, sequences with SSCP patterns A and B for ram 1 and G and H for ram 2 may encode important functional classical class I products, whereas the remaining sequences may be poorly expressed classical or non-classical class I genes.

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Effect of steam pressure and reaction time on chemical composition and bioavailability of sugar cane bagasse to rumen microbes

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Introduction Steam treatment has shown good results (Pate, 1982) for upgrading the nutritional value of low quality forages. The sugar cane industries in Iran are interested in using steam explosion for upgrading the nutritional value of sugar cane bagasse. The aim of this study was to assess the effect of steam pressure and reaction time on chemical composition and bioavailability of sugar cane bagasse to rumen microbes.

Material and methods Samples containing 50% moisture were put in stainless steel baskets and placed in reaction camber. Steam explosion of samples carried out by direct injection of steam into the chamber and the samples kept under a specific pressure and a period of time (reaction time) and then the chamber was depressurized. A complete randomized design with a 3×5 factorial arrangement with three replicates was used to assess the effect of pressure and reaction time on chemical composition, *in situ* degradation and *in vitro* gas production (GP) of the samples. Three pressures including 14, 17 and 20 atm. and 5 reaction times including 120, 180, 240, 300 and 360 seconds were used. Dry matter loss (DLM) of the samples during the treatment was determined by measuring the changes in dry matter of the samples before and after treatment. Samples were analyzed for CF, NDF, ADF, ADL, soluble carbohydrates (CHO) (Dubois *et al,* 1956) and total extractable phenolics (TEP) (Julkunen-Tiitto, 1985).

Results Both pressure and reaction time significantly affected ($P<0.01$) the chemical composition and bioavailability of sugar cane bagasse (Table 1) and an interaction was also observed ($P<0.01$) between pressure and reaction time. The nature of steam treatment was acid hydrolysis which effectively affected all cell wall fractions (Castro *et al,* 1993). Improvement in bioavailability of treated bagasse was mainly due to deploymerization of lignin to lower molecular weight of phenolics thereby reduced the physical and chemical effect of lignin on carbohydrate utilization by rumen microbes and also by increasing in the content of soluble carbohydrates through hydrolysis of hemicellulose. The changes in ADL content of the samples did not follow the same pattern as NDF and ADF which was very likely due to contribution of some artifacts from degradation of carbohydrate to ADL (Chua and Wayman, 1978).

Table 1. Chemical composition, *in vitro* and *in situ* degradability of steam treated sugar cane bagasse.

Pressure (atm(.	Reaction time (S)	%DML	%CF	%NDF	%ADF	%ADL	%CHO	%TEP	24h GP(ml)	48h *in situ*
Untreated bagasse		---	50.50^{a}	88.57^{a}	57.30^{a}	10.83^{h}	1.47^{m}	0.06^{n}	9.57^{i}	34.53^{h}
14	120	1.29	47.03^{c}	80.67^{b}	55.90^{ab}	10.23^{i}	5.21^{l}	1.65^{m}	15.17^{h}	49.17^{g}
	180	1.51	47.30^{c}	78.73^{bc}	57.33^{a}	11.43^{fg}	6.08^{k}	1.87^{l}	17.67^{g}	53.47^{f}
	240	1.72	48.90^{b}	74.57^{d}	56.67^{ab}	11.33^{g}	7.34^{j}	2.22^{j}	19.00^{f}	57.50^{e}
	300	1.94	46.80^{c}	71.43^{e}	55.30^{b}	11.23^{g}	12.45^{h}	2.48^{i}	22.43^{e}	59.13^{e}
	360	2.58	45.07^{d}	65.34^{fg}	52.30^{c}	11.47^{fg}	14.88^{g}	2.78^{h}	23.27^{e}	63.20^{d}
17	120	2.80	45.27^{d}	78.13^{c}	53.10^{c}	11.83^{edf}	8.65i	2.00^{k}	20.26^{f}	58.23^{e}
	180	3.01	43.23^{e}	65.33^{fg}	49.87^{de}	14.47^{a}	16.65^{e}	2.99^{g}	25.17^{dc}	64.33^{d}
	240	3.23	43.47^{e}	63.33^{g}	49.70^{e}	13.63^{b}	17.13^{e}	3.19^{f}	25.63^{bc}	64.63^{d}
	300	4.52	43.33^{e}	59.67^{h}	49.40^{e}	14.10^{a}	21.08^{d}	3.73^{e}	28.03^{a}	67.20^{c}
	360	5.38	41.37^{f}	56.10^{i}	47.60^{f}	13.30^{b}	21.86^{c}	4.29^{c}	26.67^{a}	67.00^{c}
20	120	3.01	42.67^{ef}	65.90^{f}	49.30^{ef}	14.33^{a}	15.48^{f}	2.81^{h}	23.43^{de}	64.73^{d}
	180	3.66	43.03^{e}	59.33^{h}	52.07^{c}	11.67^{efg}	22.54^{b}	3.97^{d}	27.37^{ab}	67.67^{c}
	240	5.59	41.87^{ef}	60.10^{h}	51.50^{dc}	12.63^{c}	22.89^{b}	4.03^{d}	27.70^{a}	70.10^{b}
	300	7.10	42.30^{ef}	56.03^{i}	52.00^{c}	12.10^{d}	25.00^{a}	5.04^{b}	29.20^{a}	71.27^{ab}
	360	9.46	41.27^{f}	54.67^{i}	51.63^{dc}	12.00^{de}	25.38^{a}	5.86^{a}	28.53^{a}	72.87^{a}
SEM(n=3)		---	0.444	1.579	0.471	0.176	1.131	0.220	0.925	1.702

Means on the same column with differing superscripts differ significantly ($P<0.05$).

Conclusion The results of this study showed that steam treatment can effectively improve the nutritive value of sugar cane bagasse. Higher pressure will need shorter reaction time to achieve the same nutritive value which obtained by using the lower pressure and longer reaction time. Longer reaction time negatively affects the dry matter loss.

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The influence of vitamin E supplementation during late pregnancy on lamb mortality and ewe productivity in Awassi ewes and their lambs

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Introduction Fetal growth in all animals is exponential with more than 60% of total growth occurring in the final 2 to 3 months of gestation. As a result of this growth pattern, there is a substantial increase in nutrient requirements for the animal in late pregnancy as compared to the needs required for maintenance or early pregnancy (Bell, 1995). Fat soluble vitamins like vitamins A, D and E do not appreciable cross the placenta resulting in minimal liver reserves (Njeru, 1994). This means that newborn lamb is essentially devoid of these vitamins and susceptible deficiency of disease problems. The lamb's primary source of vitamin A, D and E comes via colostrum ingestion supplied from an adequately supplemented dam. The objective of the current study was to determine the effects of dietary vitamin E supplementation during late pregnancy on Awassi fat-tailed lamb mortality and ewe prolificacy.

Material and methods Three weeks before the first expected lambing date, fifty two pregnant Awassi ewes (6 years aged) were divided into two groups; supplement-group ewes (n=26) were fed additional vitamin E and control-group ewes (n=26) were not. Ewes were weighed at lambing, turnout (approximately 30 d post lambing) and weaning (60 d of age) and assigned a body condition score from 1 to 5 (1 = extremely thin; 5 = obsess). Three weeks before the first expected lambing date, ewes were fed 1.5 kg/d of dry grass hay and .35 kg/d of barley plus .27 kg/d pellets with or without supplemental vitamin E. Supplemented pellets contained 30 mg of Vitamin E of feed, providing an additional 400 IU of vitamin E/ewe/d. Supplemented pellets were only fed until ewes lambed; thereafter, ewes were fed similarly. The data were subjected to analysis of variance according to the general linear model of SAS.

Results Compared with control group ewes, feeding additional vitamin E to ewes during late pregnancy had significantly ($p<0.05$) effect on ewe body weight at lambing and turnout and body condition score at lambing (Table 1). Fertility (percentage of ewes lambed) or prolificacy (number of lambs born per ewe) were not found significantly different. Lambs born from supplemented ewes had higher ($P<0.01$) body weights than lambs from control group ewes (Table 2). Mortality rate was 3 % for lambs in supplement group and 26 % for lambs in control group. Vitamin E supplementation of ewes in late pregnancy was found to significantly ($P<0.05$) increase lamb vigor. Because of this increased survivability, total lamb production was 3.7 kg greater per ewe in the vitamin E supplemented group.

Table 1. Ewe body weights and contiditions

	Group		
Variable	Control	Supplement	P values*
Ewe body weight (kg)			
Lambing	51.29± 2.00	57.09± 1.83	0.04*
Turnout	44.26± 1.27	48.75± 1.39	0.02*
Weaning	46.16± 1.22	49.56± 1.33	0.06
Ewe body condition score			
Lambing	3.1± 0.17	4.5± 0.18	0.00*
Turnout	3.4± 0.17	3.6± 0.18	0.42
Weaning	3.5± 0.15	3.6± 0.16	0.47

Table 2. Reproductive characteristics of ewes and body weights and survivability rate of lambs

	Group		
Variable	Control	Supplement	P *
Ewe reproductive values			
Fertility (%)	97.8	98.4	0.57
Prolificacy	1.21± 0.08	1.12± 0.09	0.51
Lamb body weight (kg)			
Birth	3.8± 0.14	4.6± 0.16	0.00*
Turnout	7.9± 0.60	8.5± 0.63	0.41
Weaning	15.6± 0.87	14.7± 0.93	0.47
Survivability (%)	74	97	0.03

Conclusion Feeding of vitamin E in late pregnancy reduced lamb mortality until weaning. Supplemented ewes with vitamin E not only had better body condition at lambing but also reared more lambs. Increase in lamb survivability obtained in this study offers the potential for more lambs produced per exposed ewe.

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Levels of mucous IgA in response to gastrointestinal nematode in sheep

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Introduction Genetically resistant sheep have been found to exhibit a significantly higher anti-parasite antibody response than random-breed sheep. Increased concentrations of serum IgG and local IgA have been associated with resistance to gastrointestinal parasites (Gill et al., 1993). In the present study, we examined the levels of IgA antibodies in abomasal mucous of naturally and artificially infected sheep of Santa Inês and Europeans breeds of sheep, respectively, resistant and susceptible to *Haemonchus contortus* infection (Amarante, et al., 2004).

Material and Methods In the experiment I (Exp. I), 33 male lambs of three breeds (Suffolk, Ile de France and Santa Inês) were raised in a pasture during 10 months. After this period, the lambs were slaughtered. In the experiment II (Exp. II), four-month-old male Ile de France (IF) and Santa Ines (SI) lambs, 24 of each breed, were trickle infected with 300 *H. contortus* L_3, three times per week for 12 weeks. Similar number of animals of each breed was kept without infection (control groups). The lambs were slaughtered at the end of the 12-week experiment. Mucous samples were taken from abomasums and worm burden were determined in the slaughtered sheep in both experiments. ELISA (Huntley et al., 1998) was used to determine anti-parasite IgA antibodies in mucous against *H. contortus* larvae (L3) and adult (L5) antigens. ANOVA was used to assess effects of breed in IgA levels with SAS (Proc GLM).

Results Santa Inês lambs had a lower EPG counts and *Haemonchus* burden than other breeds in both experiments (P<0,05). *Trichostrongylus* spp. was the most abundant nematode in the pasture followed by *Haemonchus* spp. and *Cooperia* spp. In the Exp. I, there was no significant difference in the IgA concentration between breeds against *H. contortus* (L3) and (L5) antigens. In the Exp. II, the SI infected group showed high IgA levels against L5 antigen than the other groups (p<0.05), however, there was no significant difference among IgA means against L3 antigen (Figure 1).

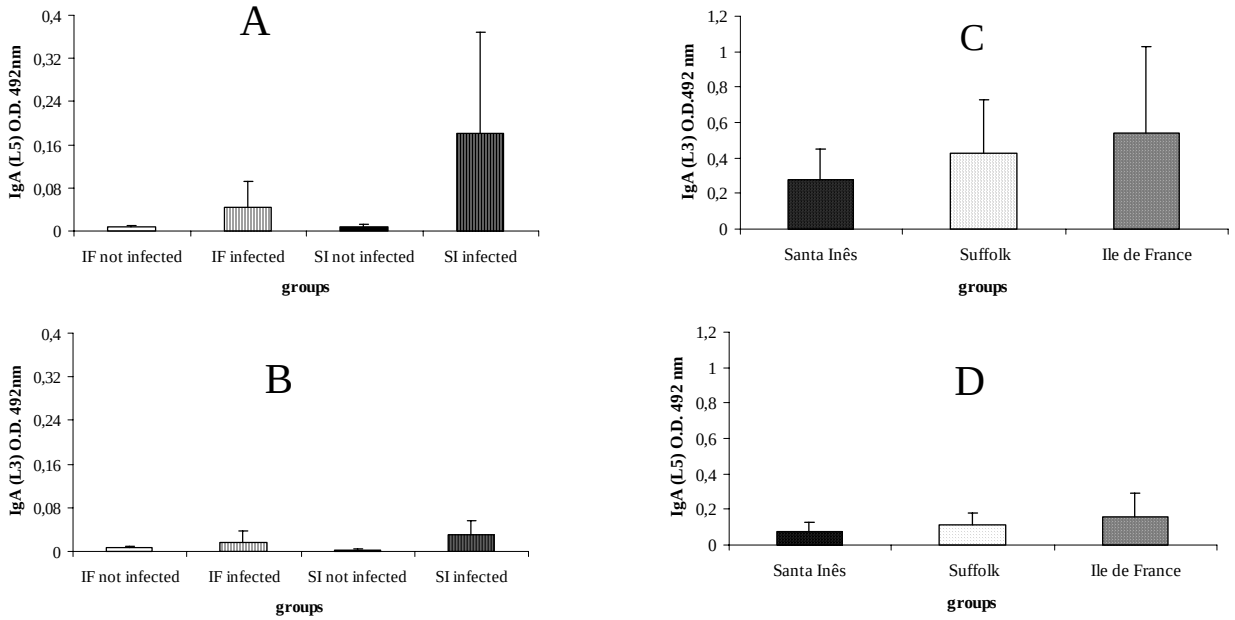

Figure 1. Means of mucous IgA levels in the abomasums of sheep of the Exp. I (A and B) and Exp. II (C and D).

Conclusion After trickle artificial infections with *H. contortus*, IgA antibody response to adult worm antigens was higher in the native SI when compared to the European IF sheep. However, no breed difference in IgA response was detected in naturally infected sheep. We observed higher IgA titles in Exp. I than in Exp. II probably because the challenge in the pasture was more effective than artificial infection to activate the local immune response.

Acknowledgements This study was supported by FAPESP (São Paulo - Brazil) and Moredun Research Institute.

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Supplementation of maize stover with cowpea on growth performance of sheep

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Introduction

While livestock sector is the back-bone of Ethiopian economy, production levels are low due to a variety of causes. It is characterized by low milk production, poor growth rates, extended calving or lambing intervals and a relatively late age at maturity. The major constrain for this is seasonality of feed quality and poor availability during the dry season, with nitrogen supply especially limiting. However legume forages such as cowpea offer the possibility to enhance dietary N levels and improve livestock production (Abule *et al*., 1995). With its quick growth, drought resistance and rapid ground cover cowpea has become an essential component of sustainable subsistence agriculture in marginal lands and drier regions of the tropics. This study was conducted to examine the ability of cowpea forages, offered as a supplement to low quality maize stover, to enhance intake and production performance in growing Ethiopian highland sheep.

Materials and methods Two cowpea accessions were selected by considering agronomic data (forage and grain yield, leaf to stem ratio) from field evaluation trials at two sites in Ethiopia. The accessions used 12688 (C1, a forage-type) and IT96D-774 (C2, a dual-purpose type) were offered as dried crop residues following grain harvest. A randomised block design with six treatments groups of eight sheep (blocked by weight) was used. All sheep were offered maize stover (MS), chopped to 10 cm, *ad lib* plus 3g bone meal and 2g salt each day. Six treatments were compared, viz; a negative control - no supplement, a positive control - commercial concentrate (CC) 300 g d^{-1}, based on wheat bran and nuge cake (879 and 121 g kg^{-1} DM, respectively) and the two cowpea accessions was offered at either 150 or 300 g d^{-1}. The MS, CC and cowpea accessions (C1 and C2) had 38, 184, 185 and 168 g CP kg^{-1} DM and 916, 887, 923 and 924 g kg DM^{-1}, respectively. The growth performance trial was conducted for 93 days with four animals from each treatment group randomly selected for a digestibility trial (8 days collection) during the last two weeks of the study. Feed refusal, urine and faeces were collected daily and sub-samples were analysed for DM, ash, N, NDF and ADF. Sheep were weighed initially and every fortnight for three consecutive days through out the trial. SAS GLM procedures were used for the analysis of feed intake, digestibility and growth parameters.

Results Cowpea supplementation significantly increased MS intake, relative to the controls, however the slightly lower intakes with 300 g cowpea suggested partial substitution. In contrast supplementation with CC had no effect on MS intake. Total N levels increased from 2.3g d^{-1} (unsupplemented controls) to 10.2 g with CC and 11.6 and 10.5, for C1 and C2 at 300 g d^{-1}. Average daily gain increased significantly with both levels of cowpeas supplementation, relative to the unsupplemented controls and was greatest at the highest level of supplementation. The CC treatment provided the highest rate of gain while the unsupplemented control animals lost weight. Carcase weight and dressing percentage followed the same pattern, with nitrogen retention closely following supplementation level. Both OM and NDF digestibility were enhanced with supplementation, with the greatest overall improvement occurring with the CC.

Table 1 Mean for intake, digestibility and weight gain for treatment groups

Treatment	Controls		C1		C2		
Parameters	-	+	150	300	150	300	se
MS intake, g	363^{b}	363^{b}	440^{a}	400^{ab}	424^{a}	412^{ab}	49
Daily N intake, g	2.3^{a}	10.2b	7.5c	11.6^{a}	6.7^{d}	10.5^{b}	0.41
Initial live weight, kg	19.28^{a}	19.93^{a}	19.23^{a}	19.61^{a}	19.32^{a}	19.43^{a}	1.28
Average daily gain, g	-26^{d}	62^{a}	33^{c}	48^{b}	24^{c}	51^{b}	10
Carcass cold weight, kg	5.40^{d}	11.08^{a}	8.53^{c}	9.93^{b}	7.98^{c}	9.65^{b}	0.63
Dressing, %	31.9^{d}	43.2^{a}	38.4^{c}	41.5^{b}	37.1^{c}	40.1^{b}	1.5
Organic matter digestibility, g kg^{-1}	453^{c}	625^{a}	575^{b}	597^{ab}	590^{b}	585^{b}	20
NDF digestibility, g kg^{-1}	445^{b}	567^{a}	590^{a}	590^{a}	583^{a}	585^{a}	35
Nitrogen retention, g	-0.3^{d}	1.1^{c}	1.5^{cb}	2.1^{ab}	1.7^{abc}	2.4^{a}	0.51

Means in rows without common superscript different significantly ($P<0.05$)

Conclusions The results indicate that supplementation with as little as 150 g cowpea crop residue per day was found to stimulate intake, through enhanced ration digestibility, and significantly increase liveweight gain. A similar response was observed with commercial concentrate but due to cost and availability this is unlikely to have been as economically rewarding. When considered in the context of a mixed system, where cowpeas also provide a high protein grain crop, reduce soil erosion, water loss and invasive weeds plus improve soil fertility, this crop offers a remarkable potential to enhance smallholder livestock production in Ethiopia.

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The contribution of small ruminants to soil fertility management in the forest and savannah zones of Ghana

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Introduction The amount and nutrient content of small ruminant manure and its consequent value as a soil ameliorant will be largely determined by their diet (chemical composition of the plants consumed and their digestibility), and the efficiency of digestion, and will vary accordingly (Delve et al, 2001). This comparative study set out to evaluate the current and potential contribution of sheep and goats to soil fertility management in two villages located in different ecological zones in Ghana.

Materials and methods Two villages in Ghana were chosen for the study, one located in the forest zone (Gogoikrom) and one located on the southern fringe of the savannah zone (Yabraso). Data on livestock numbers was collected in this and another study (Obiri-Darko, 2003), and an estimate of daily faecal output of 2.5 kg DM/Tropical Livestock Unit (TLU) was used (Hoffman, 2001). Fresh small ruminant faeces were collected and bulked from livestock belonging to 10 farmers in Gogoikrom, however in Yabraso, most of the animals were free ranging, and so 6 random fresh samples were collected and bulked in addition to 2 from individual pens. Total faecal nitrogen (N) was determined using the Kjeldhal method, the total phosphorus (P) by spectrophotometry using the molybdate blue method, and total potassium (K) by flame photometry. The data were analysed using the ANOVA function of MINITAB (version 13).

Results There were slight, but not significant differences between the NPK content of the faeces between the two villages. The actual contribution of small ruminants to soil fertility management was found to be negligible at best, since very few farmers used manure at all, and then only on their backyard gardens. In addition, free roaming livestock were also largely excluded from the cropland. The potential role of small ruminants however was considerable (see table 1). The average annual accretion of manure could potentially counter the nitrogen and phosphorus losses from approximately 0.58 ha of arable land in the forest zone, and 1.12 ha in the southern fringe of the savannah zone.

Table 1 The potential contribution of small ruminant faeces to soil fertility inputs

	Gogoikrom	SE	Yabraso	SE	P
Total N (g/kg DM faeces)	23.94	0.08	25.43	0.04	0.175
Total P (g/kg DM faeces)	3.01	0.03	2.76	0.02	0.406
Total K (g/kg DM faeces)	7.31	0.77	6.60	0.85	0.504
Mean TLU/livestock farmer	0.64		1.22		
Annual small ruminant faeces/livestock farmer (kg DM)	584		1113		
Estimated potential annual N:P:K resources/livestock farmer (kg)	14: 2: 4		28: 3: 2		
Estimated annual N:P:K losses/ha of arable land	23: 2: 14		25: 2: 15		
Nutrient balance/ha (kg N:P:K/ha)	-9: 0: -10		3: 1: -13		
Potential area (ha) of arable land fertilised by manure (N:P:K)	0.58: 1: 0.29		1.12: 1.5: 0.13		

Conclusion

Whilst the potential of small ruminants to be integrated into cropping systems in the two study villages was great, there were logistical and socioeconomic constraints to doing so. Some farmers were aware of the benefits of using manure, though lack of knowledge was often cited as a reason for not doing so. In addition, many farmers perceived their soil fertility management method (bush fallow) to be sufficient without fertiliser addition, especially manure since it requires a large labour commitment. Until soil fertility is perceived to be in decline (i.e. through falling crop yields), it is unlikely that farmers will adopt this approach. However with increasing land pressure from rising population, farmers may reevaluate the cost/benefit of using their small ruminant manure. Furthermore, were the benefits of using manure to be clearly demonstrated through trials, they may adopt this technology before they are forced to do so.

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The effect of age on the levels of lipogenic enzymes in subcutaneous fat and muscle of pigs

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Introduction Understanding the mechanisms that regulate the formation of subcutaneous and intramuscular fat (IF) Is important in improving meat quality. Formation of IF is a process, which occurs in the later stages of development, perhaps due to age-related changes in expression of lipogenic enzymes. Acetyl CoA carboxylase (ACC) and fatty acid synthase (FAS) are the key enzymes in the process of *de novo* synthesis of fatty acids. Delta-9-desaturase (d-9-d) is another key lipogenic enzyme, which catalyses conversion of saturated fatty acids (synthesised *de novo* as well as dietary) to monounsaturated. The objective of the present research was to investigate the levels of ACC, FAS and d-9-d in the subcutaneous fat and muscles of pigs of different ages.

Materials and methods Thirty Meishan x Large White male pigs were used in the study. Half of the animals had been castrated at birth under veterinary supervision. The animals were fed a standard pelleted feed and slaughtered at the age of 114, 144 and 174 days (five boar and five castrated pigs per each age group). The diet contained 14 MJ/kg Digestible Energy, 170g/kg crude protein and 1.1g/kg lysine. Samples of subcutaneous fat and the *longissimus* muscle were frozen in solid CO_2 and subsequently stored at –80 ^{o}C. Cytosolic and microsomal fractions were isolated by differential centrifugation. The levels of ACC and FAS in cytosol and the level of d-9-d in microsomes were measured by Western blotting using polyclonal sheep antibodies against rabbit mammary gland ACC and FAC or rabbit polyclonal antibody against porcine d-9-d. Significance of differences was assessed using Sudent's *t*-test.

Results The levels of ACC, FAS and d-9-d in subcutaneous fat were low in 114d animals, increased at 144d and significantly declined in 174d pigs (Table 1). In muscles d-9-d level was decreased between 114-144 days and then significantly increased in 174d animals. Thus, the pattern of age-related changes of d-9-d in muscles showed the opposite trend to the pattern in subcutaneous fat. The levels of ACC and FAS in muscle were approximately the same in all age groups. Castration led to an increase in the d-9-d level in both tissues (Fig 1 and 2).

Conclusions The results suggest that the mechanisms regulating expression of the lipogenic enzymes in subcutaneous fat and muscles are different. Sex hormones might be one of the factors regulating d-9-d expression.

Table 1 Relative amount of lipogenic enzymes (arbitrary units) in subcutaneous fat and *longissimus* muscle of pigs of different age

	Age (days)		
	114	144	174
	Subcutaneous fat		
ACC	0.74 ± 0.17*	2.06 ± 0.21	0.71 ± 0.16***
FAS	0.88 ± 0.14*	1.67 ± 0.16	1.08 ± 0.13*
D-9-d	18.7 ± 5.7*	54.6 ± 13.5	14.8 ± 7.9*
	Longissimus muscle		
ACC	0.77 ± 0.03	0.67 ± 0.01	0.58 ± 0.02
FAS	0.10 ± 0.05	0.09 ± 0.04	0.06 ± 0.01
D-9-d	10.3 ± 0.74*	6.7 ± 1.2	13.0±2.6*

The data are presented as the mean ± SEM.
* P<0.05 , ***P=0.001 (when compared with 144d)

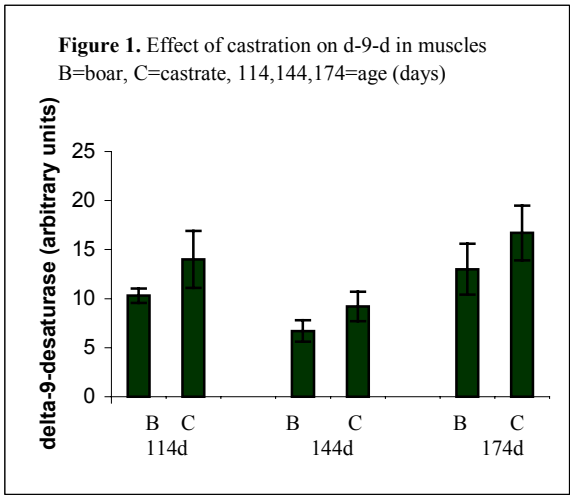

Figure 1. Effect of castration on d-9-d in muscles B=boar, C=castrate, 114,144,174=age (days)

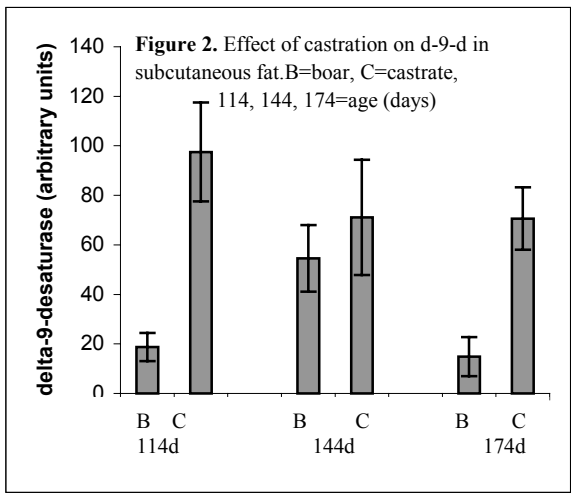

Figure 2. Effect of castration on d-9-d in subcutaneous fat.B=boar, C=castrate, 114, 144, 174=age (days)

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Effects of breed and diet on fat deposition in pigs

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Introduction Breed and diet are important production factors in pigs, affecting growth rate and fat deposition. Subcutaneous fat and intramuscular (marbling) fat are important for carcass and meat quality and this study has investigated how these two fat depots are affected by breed and diet.

Materials and Methods One hundred and ninety two entire male pigs were used, consisting of approximately equal numbers of Berkshire (Berk), Duroc (Dur), Large White (LW) and Tamworth (Tam) breeds. They were fed from 9 weeks of age for a 12-week period on a conventional diet, C (14 MJDE, 11.9 g lysine/kg) or a low protein diet, LP (13 MJDE, 7 g lysine/kg) which also had a higher energy:protein ratio. A 4 (breeds) x 2 (diets) experimental design was used. After slaughter, when P_2 fat thickness was measured, the foreloin joint was dissected into its constituent tissues and total lipid (marbling fat) was extracted from totally defatted *longissimus* and *psoas* muscle cross sections using chloroform:methanol (2:1). Data were analysed by general linear model procedures (SAS GLM).

Results Fat thickness was higher in Berk and Tam than Duroc and LW ($P<0.01$) (Figure 1). The diet effect was not significant ($P>0.05$). The same breed effects occurred in subcutaneous fat which was significantly higher in LP in all breeds ($P<0.01$). Marbling fat in *longissimus* and *psoas* was higher in Berk and Duroc than LW and Tam (different breed order than subcutaneous fat) ($P<0.05$) and was higher in LP than C ($P<0.01$). The impact of the LP diet on fat deposition was greater in the two modern breeds than the two traditional breeds and more pronounced in marbling fat (Table 1).

Table 1 Ratios of diets LP/C for subcutaneous and marbling fat.

	Marbling fat	Subcutaneous fat
Berk	1.75	1.10
Duroc	1.94	1.36
LW	2.15	1.46
Tam	1.20	1.13

Figure 1. P2 fat thickness (mm)

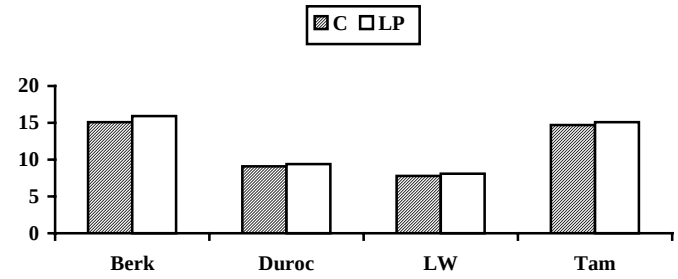


Figure 2. Subcutaneous fat (g/100g foreloin)

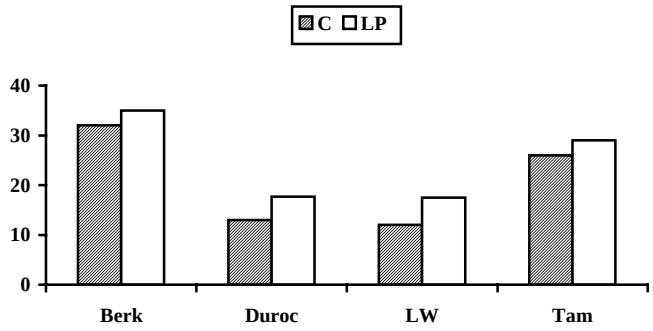


Figure 3. Marbling fat longissimus(g/100g muscle)

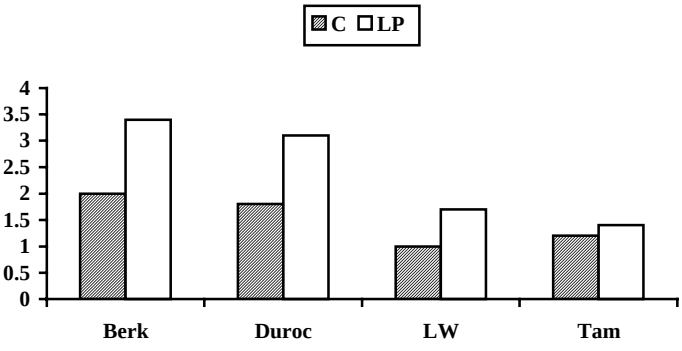
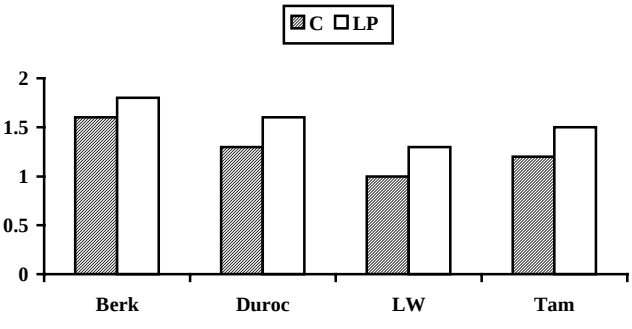


Figure 4. Marbling fat psoas (g/100g muscle)



Conclusions The two traditional breeds, Berk and Tam, had more subcutaneous fat than the two modern breeds on diet C and the fat promoting effect of diet LP was proportionately smaller. Marbling fat, which was higher in the white *longissimus* than the red *psoas* muscle, was increased more than subcutaneous fat by the LP diet. There was a large breed effect on the partitioning of fat between subcutaneous and intramuscular depots. Duroc, with a lean carcass, had high marbling fat and Tam, with a fat carcass, had low marbling fat.

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Effect of breed, diet and weight on pork fat quality and processing characteristics in pigs

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Introduction The processing characteristics of pork fat are influenced by its fatty acid composition. Poor slicing quality of floppy belly bacon is caused largely by soft fat. High concentrations of saturated fatty acids (SFA) particularly stearic acid (18:0) and low concentrations of unsaturated fatty acids (USFA) mainly, linoleic (18: 2) improve firmness/hardness of fatty tissues (Wood *et al*, 1985). The physical properties of fat also influence the stability of emulsion-type meat products through fat loss during cooking. Losses of 0.8 from hard pork flare fat and 0.2 from soft jaw fat have been reported (Evans and Ranken, 1975). The objectives of this study were to evaluate the effects of breed, diet and slaughter weight on the fatty composition of pork fat and the quality of belly bacon and frankfurter sausage.

Materials and methods Thirty-two pigs, equal numbers of males and females from 2 breeds; PIC 225 (Large White type) and PIC 408 (Pietrain type) and an average initial live weight of 45kg were used. Pigs were housed in groups of 16 in straw-based pens and fed *ad lib* two diets with 14 MJDE/kg and 2 lysine levels, normal (11g/kg HL) and low (7g/kg LL). Eight animals from each breed were slaughtered at 40 and 80 days of the trial. Meat quality data collected after slaughter included, fat firmness at 2^{o}C with a digital penetrometer. Strips of shoulder and loin fat, 20cm x 5cm, were placed halfway over the edge of the bench to determine the angle of bending. Analysis of backfat fatty acid composition was by GLC. Slip point was determined by the open capillary method. Ten 4mm thick slices from each cured belly were subjectively evaluated with saleable slices graded A. Cohesion in bacon was assessed by a tensile test on cylindrical samples of 25mm diameter. Pork frankfurter sausages formulated with 5kg lean + 2kg fat from the shoulder and neck were cooked individually in sealed vacuum-packed polyethylene bags at 80 ^{o} C for 1h. Fat loss in the exudates was determined gravimetrically. Data were analysed by balanced ANOVA with breed, diet and days on trial as main factors. Correlations between fatty acids and fat firmness, bacon quality and fat loss from sausages were determined.

Results Mean carcass and meat quality are given in Table 1. The relationships between fatty acid concentrations and quality charateristics are given in Table2. Days on trial affected carcass weight, fat firmness and P2. Fat firmness, slip point and cohesiveness had moderately to good positive relationships with SFA and good negative relationships with USFA and polyunsaturated to saturated fatty acid ratio (P: S). Fat loss was positively related to SFA and C18:0 / C18: 2 and negatively related to USFA. Cohesion and grade A, bacon slices were highly correlated (r=0.8)

Table 1 Effect of days on trial, diet and breed on pork carcass and backfat quality

Variables	40d	80d	HL	LL	225	408	Pooled s.e.d	Sig: Days on trial	Diet	Breed
Cold weight (kg)	55.1	80.7	70.8	65.0	69.1	66.7	2.63	***	*	ns
P2 (mm)	11.9	15.6	13.6	13.9	14.1	13.4	1.23	*	ns	ns
pH45	6.3	6.3	6.4	6.3	6.5	6.4	0.08	ns	ns	ns
pHu	5.5	5.5	5.5	5.5	5.5	5.5	0.02	ns	ns	ns
Fat firmness										
Shoulder **(Pe)**	616	730	708	639	690	656	31.60	**	*	ns
,, (angle)	54	33	38	50	38	49	5.53	**	*	ns
Loin **(Pe)**	421	514	497	438	480	455	43.21	*	ns	ns
,, (angle)	73	47	58	63	55	64	5.0	***	**	ns
Slip point (^{o}C)	27.1	29.2	29.3	27.1	28.4	28.0	0.7	**	**	ns

Pe: penetrometer units; NS: not significant; *: P ≤ 0.05; **: P≤ 0.005; ***: P≤ 0.001

Table2 Correlation between fatty acid concentrations and fat qualities

Fatty acids	Shoulder	Loin	Slip point	Bacon cohesion	Grade A slices (%)	Sausage fat loss
16:0	+ 0.7***	+0.4*	+0.6**	+0.5*	+0.3ns	+0.8**
18:0	+0.7***	+0.6**	+0.6***	+0.6***	+0.5**	+0.7**
18: 2	-0.6***	-0.4*	-0.4*	-0.3ns	-0.4*	-0.5*
18: 3	-0.5**	-0.3ns	-0.5**	-0.3ns	-0.3ns	-0.6*
18:0/C18:2	+0.7***	+0.5	+0.6***	+0.5**	+0.5**	+0.7**
P: S	-0.7***	-0.6**	-0.6**	-0.5*	-0.4*	-0.6*

NS: not significant; *: P ≤ 0.05; **: P≤ 0.005; ***: P≤ 0.001

Conclusion The results show that factors which change fatty acid composition, e.g. days on trial, also affect processing characteristics in pigmeat. While a higher content of SFA may be beneficial in the production of belly bacon, it may not favour frankfurter sausage production because it increases fat loss during cooking.

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The development of an assay to measure serum levels of transthyretin: a new health status indicator in the pig

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Introduction: Transthyretin (TTR), also known as thyroxin-binding prealbumin, is a serum protein with a molecular mass of 55 kDa made up of four identical subunits. The prealbumin name is derived from its mobility during electrophoresis as it migrates faster than albumin. It is one of the three major thyroxine binding proteins and forms a complex with retinol binding protein to aid the transport of vitamin A in plasma. TTR is a negative acute phase reactant and serum levels fall due to decreased synthesis in inflammation, malignancy and protein wasting diseases of the gut or kidney. Human serum levels of TTR are measured in diagnostic laboratories as an indicator of health status and a number of commercial assays are available for this purpose. However, such tests have yet to be established for the pig. The aim of this study was to develop an assay to measure TTR in porcine serum.

Materials and Methods: After testing commercially available antibodies to human TTR for cross reactivity with porcine serum using immunoblotting the IgG fraction of sheep anti-human prealbumin (ICN, UK) was used to develop an assay for TTR in pig serum. Purified human TTR and human serum were used as standard and positive control. Pooled serum from healthy pigs, serum from 209 individual healthy pigs and purified porcine TTR fractions were used to develop the assay. Microtitre plate wells were coated with purified TTR or serum samples diluted in 100 mM Sodium Carbonate pH 9.5, and blocked with 5% (w/v) non fat milk in phosphate buffered saline, 0.1% (v/v) Tween 20 (TPBS). The plates were then incubated with the anti-human TTR antibody diluted in TPBS. After incubation the plates were washed with TPBS and the second antibody (anti-sheep IgG peroxidase conjugate (Sigma-Aldrich, UK)) was added to each well and incubated at room temperature. The plates were then washed with TPBS as before. Peroxidase substrate was then added to each well and the O.D. read at 450 nm. Different antibody concentrations, incubation times and sample dilutions were tested in order to optimise the assay conditions.

Results: The lower detection for TTR in the assay was determined as 32 μg /ml. The interassay precision (CV) of 12.94 % was obtained by measuring the same sample in 7 separate assays. The intraassay CV was ascertained to be 9.14 % by quantifying the same sample 10 times in the same assay. The TTR concentration for human serum pool was 346 ± 15 μg /ml (± SE, n=5) and for the porcine serum pool was 164 ± 9 (± SE, n=7). The values for the 209 individual pig serum samples measured ranged from 32 to 690 μg /ml with a mean value of 139 ± 109 μg /ml.

Conclusions: An assay, which can measure TTR in porcine serum, has been developed. However, more work is required to further characterise and optimise the assay so it can be used routinely. In particular measurement of TTR serum levels during different infections and diseases will aid in establishing TTR as a health status indicator in pigs.

Effect of supplementing piglet diets with Rovimix® Stay C® 35 and/or iron on plasma unbound iron and vitamin C levels

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Introduction Vitamin C is a dietary component that enhances bioavailability of inorganic ferric iron (Fishman et al., 2000). However, vitamin C is unstable in the presence of alkali and it might be destroyed in the duodenum (Arrigoni, and De Tullio, 2002). The aim of this study was to investigate the effect of supplementing piglets with Stay C®35, a stable preparation of Vitamin C on plasma unbound iron and vitamin C status in piglets.

Material and Methods One thousand and eighty three piglets were weaned at a mean age of 24 days and allocated according to treatment on to fully slatted pens (50 piglets per pen). Treatment diets were as follows: Control 1 (C1): standard weaning diet with 200mg/kg of dietary iron. Control 2 (C2): standard weaning diet with 120 mg/kg of dietary iron. Treatment 1(T1): standard weaning diet with 120 mg/kg of dietary iron plus 50mg of L-ascorbyl-2-phosphate (Rovimix® Stay-C® 35) containing 35% Vitamin C. Treatment 2 (T2): standard weaning diet with 120 mg/kg of dietary iron plus 200 mg of Rovimix® Stay-C® 35. The experiment was done over 4 replicates each with approximately 200 piglets. Within each replicate 50 piglets were allocated to each treatment. Within each replicate fourteen animals from each dietary treatment were blood sampled at weaning and twenty-eight days after weaning. Plasma unbound iron and vitamin C were analysed using ABX diagnostics Ferrozine Iron kit and the method of Lee et al, (1997) respectively. Plasma concentrations were compared by statistical analysis using the General Linear Model (GLM) (Minitab 13.0, Mintab, Inc, PA. USA). Significant treatment differences were reported at ($p<0.05$).

Results There were no significant differences ($p>0.05$) in plasma unbound iron and vitamin C levels at weaning in animals in groups C1, C2, T1 and T2. At day twenty-eight post weaning, animals in C1 had significantly higher ($p<0.05$) levels of unbound iron when compared to all the other groups. There were no significant differences ($p>0.05$) between C2, T1 and T2. Plasma vitamin C levels in animals in treatment 2 were significantly higher ($p<0.05$) than animals in control 1 and treatment 1. There were no significant differences ($p>0.05$) in plasma vitamin C levels between treatment 1 and treatment 2. No significant differences ($p>0.05$) were found in plasma vitamin C levels between C1, C2 and T1.

Table 1. Effect of Rovimix® Stay C® 35 on plasma Unbound Iron and Vitamin C levels (umol/litre) at weaning and twenty-eight days post-weaning in piglets.

		Control 1 (n=56)	Control 2 (n=56)	Treatment 1 (n=56)	Treatment 2 (n=56)
Unbound Iron	Day 0	27.4 ± 2.9	29.5 ± 2.8	31.6 ±2.9	29.8 ± 2.6
	Day 28	31.8^{b} ±1.2	19.8^{a} ± 1.5	19.6^{a} ±1.8	20.6^{a} ±1.7
Vitamin C	Day 0	41.8 ±2.1	37.5 ±2.0	42.4 ±1.8	35.3 ±2.4
	Day 28	26.8^{a} ±1.5	33.2^{ab} ±2.6	30.7^{a} ±13.1	40.0^{b} ±2.4

Values are means ± SEM. Means with different superscripts on the same row are significantly different $p<0.05$.

Conclusion
The results from this experiment indicate that feeding piglets on a stable Vitamin C source (Rovimix® Stay-C® 35) enhances vitamin C status, although this effect can also be sustained by including lower levels of iron in the diet, thereby sparing the physiologic requirements for vitamin C (Control 2), although this could have consequences on iron supply and metabolism, thereby impacting on growth and health of piglets.

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The influence of teat-order on the pre- and post-weaning growth performance of piglets weaned at 3, 4 and 5 weeks of age

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Introduction The nutritional impact of weaning may, to a large extent, be determined by the milk consumption of the piglets prior to weaning, as piglets suck their 'home' teat (Spinka *et al.,* 1995). Since piglets possess a specific teat order and the production of milk from different teats on the same sow may differ by as much as 200% or more (Algers *et al.*, 1990), different piglets within the same litter can be assumed to be affected differently by the nutritional change. This experiment was conducted in order to evaluate the influence of teat-order in pre- and post-weaning growth performance of piglets weaned at 3, 4 and 5 weeks of age**.**

Materials and Methods The experiment was conducted according to a randomised block design, with two replicates and three treatments. A replicate comprised of six litters weaned at 3, 4 or 5 weeks of age respectively. Finally, nine sows were selected with similar litter-sizes. For each weaning age, six piglets were selected (the 2 heaviest, the 2 lightest and the 2 piglets closest to the median weight of the litter at weaning). All the piglets in the litter were identified by means of a unique combination of coloured stripes on their backs. The piglets have been monitored, using a time-lapse video recording device, 24 hours a day, from day 14 of their life to the respective date of weaning. Once the selection has been made at weaning, the sucking behaviour of the chosen piglets (n=54) was analysed from videotapes using *Observer 3.0* software. At the end of the experimental period, piglets weaned at 3, 4 and 5 weeks of age were observed for 336, 504 and 672 hours respectively for each litter. The experiment was divided into two phases. **First phase:** Piglets were weighed at birth and subsequently every seven days. Piglets had their teeth and tails clipped and were given an iron injection on the day of birth. A high quality, commercial creep feed and a drinker were provided and the daily intake of the litter was recorded from the 14th day of lactation. The sows were provided with feed according to the Stotfold Feeding Scale developed by MLC and were fed twice daily. **Second phase:** Following weaning, the piglets were offered a high quality, commercial starter diet, in pelleted form, *ad libitum.* The feed was supplied in a trough that would enable all 6 pigs in the group to feed simultaneously. A drinker bowl was provided per group of 6 piglets. Because of the non-normal distribution of the data the values were $\log_{10}$ transformed, as appropriate, and analyses was carried out using GLM-ANOVA in Minitab 12 for Windows. However, for clarity of the presentation, untransformed values are shown in the table and text.

Results

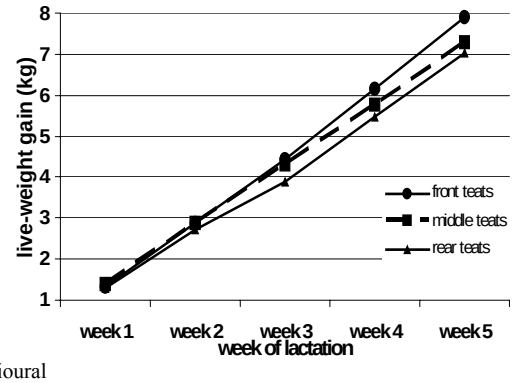
Table 1 Total sucking frequency and duration for piglets weaned at 3 different ages, in relation to scores achieved at their 'preferred' teat

Sucking Behaviour	Weaning age (weeks)			SED		
Mean values sec	3	4	5	3-4	3-5	4-5
Sucking Frequency	335	303	258	0.016	0.02 ***	0.021 ***
Sucking Duration	108019 (30h 1m)	106259 (29h 31m)	78040 (21h 41m)	5365	6886 ***	7237 ***
Preferred teat Frequency	290.7	255.3	112.57	0.626	0.80 ***	0.845 ***
Preferred teat Duration	97850 (27h 11m)	88221 (24h 30m)	34529 (9h 36m)	12.66	16.2 ***	17.09 ***

***P<0.001

SED refers to the data which have been transformed using $\log_{10}$ transformation in order to be treated with GLM-ANOVA. Due to the fact that this behavioural work was observational extensive (1512 hours of continuous monitoring), a low number of replicates was used that reduce the repeatability of some of the measures.

Figure 1 Weekly LWG of piglets sucking different positions at the udder.



Conclusion The data confirms the observations of other scientists that piglets weaned at 3 and 4 weeks of age, suckle from a preferred 'home' teat. In this study piglets spent 85% of their nursing periods sucking their 'preferred' teat. Also, it became clear that, as they grew older, piglets were looking for other nutrient sources (other teats) to satisfy their hunger, so they started to compete with their siblings for other parts of the udder. In this study, piglets weaned at 5 weeks of age, spent 57% of their nursing period stimulating and sucking their 'preferred' teat (Table 1) and the rest of their suckling time was spent stimulating other available parts of the udder. The position of the teat that the piglets nursed had no significant effect on live-weight gain, irrespective of their weaning age (Figure 1). Although piglets that suckled from the front teats were more than a kilogram heavier at 5 weeks of age than piglets suckling the posterior teats, the difference in weight was not statistically significant (P>0.05) due to the limited number of animals that were involved in the experiment.

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Effect of supplementing piglet diets with Rovimix® Stay C® 35 and/or iron on growth performance.

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Introduction Iron is an essential micronutrient for piglets, which if supplemented at weaning improves the growth performance (Kamphues et al, 1992). The effects on non-haem iron uptake involve the reduction of ferric iron to ferrous iron in the acidic environment of the stomach and the subsequent formation of a stable soluble chelate, which stays in solution in the alkaline environment of the small intestine where it is absorbed. In this way the presence of ascorbic acid in the diet can influence iron uptake by enhancing dietary iron availability or preventing the binding of iron-to-iron antagonists such as polyphenolics and phytate. In addition, ascorbic acid may also increase the utilisation of haem iron by a mechanism which involves its incorporation into ferritin, possibly through facilitating the iron-stimulated translation of ferritin mRNA and preventing lysosomal ferritin degradation. (Szent-Gyorgyi, 1992). The aim of this study was to investigate the effect of supplementing piglets with a stable form of Vitamin C on growth performance after weaning.

Materials and Methods One thousand and eighty three piglets were weaned at a mean age of 24 days and allocated according to treatment on to fully slatted pens (50 piglets per pen). Treatment diets were as follows: Control 1 (C1): standard weaner diet with 200mg/kg of dietary iron. Control 2 (C2): standard weaning diet with 120 mg/kg of dietary iron. Treatment 1(T1): standard weaner diet with 120 mg/kg of dietary iron plus 50mg of Rovimix® Stay-C® 35.Treatment 2 (T2): standard weaner diet with 120 mg/kg of dietary iron plus 200 mg of Rovimix® Stay-C® 35. The experiment was done over 4 replicates each with approximately 200 piglets. Within each replicate 50 piglets were allocated to each treatment. All piglets within each treatment were weighed at weaning and day 28 post weaning. Weights were compared by statistical analysis using the one-way analysis of variance (ANOVA) (Minitab 13.0, Mintab, Inc, PA. USA). Because individual feed intakes could not be recorded due to the feeding system, the FCR was calculated from the total weight for whole treatment group divided by total feed intake. It was not possible to carry out statistical comparisons on this data.

Results At weaning there were no significant differences ($p>0.05$) in liveweight between the experimental groups. At 28 days post weaning piglets in control 2 had significantly lower weights compared to C1, T1 and T2. There were no significant differences ($p>0.05$) in weights between control 1, treatment 1 and treatment 2. Treatment 2 had significantly higher total gain and daily gain when compared to control 2. There were no significant differences between control 1, treatment 1 and treatment 2. FCR was higher in control 1 and 2 and was lowest in treatment 2.

Table 1 Effect of Supplementing Piglet Diets with Rovimix® Stay C® 35 and/or Iron on live weights, total and daily gain and FCR in piglets

	Control 1 (n=56)	Control 2 (n=56)	Treatment 1 (n=56)	Treatment 2 (n=56)
Weaning	7.2^{a}±0.08	7.1^{a}±0.9	7.1^{a}±0.8	7.2^{a}±0.8
Weaning + 28 days	16.9^{ab}±0.2	16.3^{a}±0.23	17.5^{b}±0.7	17.0^{ab}±0.21
Total gain (kg)	9.7^{ab}±0.16	9.2^{a}±0.19	10.4^{b}±0.69	9.8^{ab}±0.17
Daily gain (g/d)	349.2^{ab}±6.05	327.5^{a}±6.91	370.9^{b}±24.65	351.0^{ab}±6.34
FCR* (Based on group)	1.34	1.34	1.25	1.22

Conclusion Due to its role in the delivery of oxygen to tissues iron deficiency and anaemia are associated with reduced growth performance in piglets. Dietary factors which enhance the gastrointestinal absorption of iron and its subsequent utilisation for incorporation into haem and non-haem proteins capable of transporting oxygen (haemoglobin) or electrons (iron-sulphur proteins of the mitochondrial electron transport chain) have the potential to enhance growth performance. The results from this study indicate that feeding piglets on a stable source of Vitamin C, even at a lower supply of iron enhances growth performance and feed conversion efficiency in piglets.

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The interaction between crude protein concentration and lactose level on piglet performance and nitrogen metabolism post weaning

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Introduction Environmental problems in pig rearing have led to intensive efforts to reduce nitrogen excretion (NE) while maintaining constant production levels. High concentrations of lactose in piglet diets have been shown to improve N digestibility (ND) (O'Doherty *et al.*, 2002) and increasing the digestibility of the feed N is a major factor in reducing NE to the environment. The hypothesis of this study is that high lactose inclusion will allow for reduced crude protein (CP) concentrations in post weaning diets.

Materials and Methods The experiment was designed as a 2 x 3 factorial (2 lactose (Lactofeed 70 (LF70), Volac Feed Ltd) levels x 3 CP concentrations). 238 piglets were selected at 12 d post weaning (7.6 kg live weight). The pigs were offered their diets for a 28-day period. In a nitrogen balance study, boars of 22 kg (4 per treatment) were assigned to metabolism crates for 12 d. The pigs were offered the same diets in both studies (see Table 1).

Results There was an interaction between LF70 and CP on ADG and ADFI (Table2). At the high LF70 level there was a linear increase in ADG and ADFI with increasing CP. At the low LF70 level there was no increase in ADG or ADFI above the medium CP. Crude protein had an effect on FCR (Table 2). LF70 level had an effect on the digestibility of organic matter (OMD) and N (Table 3). CP level had an effect on NE (Table 3). There was an interaction between LF70 and CP in urine pH. At the high LF70 level, pigs offered the diets containing the high CP had a lower urine pH than pigs offered the low LF70 level. However, LF70 level had no effect on urine pH at the low or medium CP.

Table 1. Composition of experimental diets (g/kg)

Treatment	1	2	3	4	5	6
Wheat	477.5	426.75	370.0	585.0	519.75	470.25
Lactofeed 70	250.0	250.0	250.0	125.0	125.0	125.0
Soya Bean Meal	50.0	115.0	180.0	56.0	125.0	190.0
Immunopro	75.0	75.0	75.0	75.0	75.0	75.0
Full fat soya bean	70.0	70.0	70.0	70.0	70.0	70.0
Soya oil	40.0	31.0	27.0	56.5	50.0	40.0
Minerals & vitamins	26.5	24.5	23.5	27.5	25.5	27.5
Lysine	8.0	5.5	3.0	8.0	5.5	3.0
Methionine	3.0	2.25	1.5	3.0	2.25	1.25
Threonine	3.66	2.44	1.3	3.56	2.3	1.2
Tryptophan	0.457	0	0	0	0	0.350

Table 2. Interaction between CP concentration and LF70 level on pig performance

CP (g/kg)	160		185		210			Significance		
LF70 (g/kg)	125	250	125	250	125	250	s.e.m	LF70	CP	LF70xCP
Daily gain (kg/day)	0.438	0.415	0.536	0.508	0.510	0.576	0.017	n.s.	***	*
Feed intake (kg/day)	0.825	0.815	0.918	0.830	0.842	0.948	0.028	n.s.	*	**
FCR (kg/kg)	1.901	1.970	1.718	1.634	1.648	1.646	0.071	n.s.	***	n.s.

Table 3. Interaction between CP concentration and LF70 level on OMD, ND, urine pH and slurry N excretion

CP (g/kg)	160		185		210			Significance		
LF70 (g/kg)	125	250	125	250	125	250	s.e.m	LF70	CP	LF70xCP
Daily DMI (kg/day)	1.21	1.33	1.16	1.27	1.18	1.26	0.101	n.s	n.s	n.s
OMD (%)	87.97	91.09	88.08	89.95	88.35	90.26	0.468	***	n.s.	n.s.
N digestibility (%)	81.46	85.10	81.81	84.49	83.46	85.54	0.967	**	n.s.	n.s.
Urine pH	6.45	7.04	7.48	7.62	8.73	7.96	0.232	n.s.	***	*
N excretion (kg/day)	0.013	0.010	0.012	0.014	0.016	0.018	0.001	n.s.	**	n.s.

Conclusions The inclusion of 250 g/kg LF70 improved nutrient digestibility and there was a linear increase in ADG and ADFI with increasing CP inclusion at the high LF70. The improved ND did not influence slurry NE.

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Evaluation of ultrasonic instruments used to predict the depth of backfat in live pigs

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Introduction Pig producers in the United Kingdom (UK) are paid on the basis of carcass weight and backfat depth at the P_2 position (65mm from the edge of the dorsal mid-line, at the level of the last rib). In processing plants, this measurement is assessed using the optical, Ulster or Hennessy probes and in live pigs measurements can be taken using various ultrasonic devices. Since backfat is considered a heritable trait (heritability value between 0.4 and 0.6) (Whittemore, 1993), it is of interest to the pig producer and breeder to measure it on live pigs when selecting for lean meat in replacement gilts and breeding boars. There are several commercially available ultrasonic devices and it is essential assessments made using these devices have strong correlations with backfat measurements taken at the processing plant. The accuracy of these correlations has not however been fully investigated. Indeed, work by Pomar *et al* (2001) indicated that assessments of fat using an Ultrascan 50 ultrasound system are only moderately accurate. The aim of this study was therefore to assess the accuracy of ultrasonic devices for backfat prediction as compared to the measurements obtained at the processing plant.

Materials and methods Two hand held ultrasonic instruments, the SFK pig Scan-A-Mode Backfat Scanner (SFK) and the Meritronics A-Mode Pulse Echo Ultrasonic machine (Meritronics) were used to estimate the backfat depth at P_2 on live pigs on the day prior to slaughter. In addition three measurements of fat depth at P_2 were taken on slaughtered pigs using an optical probe (Optical) and the Ulster probe (Ulster) and on the day after slaughter, after dissection, using a caliper (Diss.). A total of 120 pigs (60 boars and 60 gilts) were assessed. All pigs were slaughtered at 152 days. Each animal was confined in a weighbridge on the day prior to slaughter and the P_2 position was located and marked with indelible ink. This point was shaved and coupling gel (Ultrasound Gel, SCAN) applied to ensure good contact between the probe and the pig. The right side of the animal was used to correspond to the measurement made by the Ulster and optical Probe at the processing plant. Statistical differences between the results were tested by analysis of variance (ANOVA) and by regression analysis.

Results

The mean fat depth at P_2 predicted by the ultrasonic instruments were significantly different (11.67 vs. 10.98mm) (Table 1). However, the SFK instrument was found to predict fat depth at P_2 accurately when measured by either the optical or Ulster probe. Dissection of the carcasses, and measurement of fat depth at P_2 using calipers (Diss.) resulted in a significantly lower mean value (10.44mm) than those obtained from the SFK instrument (11.67mm) and the Optical (11.39mm) and Ulster (11.57mm) probes. However, as presented in Table 2 the relationships between all the methods of fat depth at P_2 determination were significant ($P<0.001$). The strongest relationship ($R^2 = 0.886$) was observed between the optical and Ulster probes indicating that these instruments are compatible.

Table 1 Mean fat depth at P_2 (mm) obtained from the five methods of measurements.

	P_2 (mm)	SD
SFK	11.67^{c}	2.03
Meritronics	10.98^{ab}	2.09
Ulster	11.57^{c}	2.38
Optical	11.39^{bc}	2.41
Diss.	10.44^{a}	2.32
sem	0.196	
P	< 0.001	

Means with the same superscript are not significantly different

Table 2 Regression coefficients (R^2) between the five methods of measurements.

	SFK	Meritronics	Ulster	Optical	Diss.
SFK	-	0.854	0.713	0.755	0.700
Meritronics	-	-	0.690	0.738	0.657
Ulster	-	-	-	0.886	0.755
Optical	-	-	-	-	0.769
Diss.	-	-	-	-	-

All correlations were significant ($P<0.001$)

Conclusions The R^2 values suggest that both ultrasonic devices are accurate in predicting fat depth P_2 as determined by the optical and Ulster probes. This is in contrast to that reported by Pomar *et al* (2001). However, the mean values suggested that the Meritronics instrument underestimated fat depth in relation to the Ulster probe. This is a significant finding, indicating that the SFK instrument may be more accurate for use in the selection of breeding gilts and boars. The values obtained by caliper measurement were low which may be attributed to drip loss during carcass chilling. An accurate value for drip loss is required in order for a correction factor to be determined to allow Diss. values to be truly comparable with the other values.

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The effect of dietary energy source on performance of growing pigs

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Introduction Cereals are commonly used in pig diets as the main sources of energy. However, depending on price and availability, diets of equivalent energy content can be formulated using combinations of oil and cereal by-products. The use of oil as an energy source has been shown to improve average daily gain (ADG) feed efficiency and increase digestible energy intake (DEI) (Overland *et al* 1999). However, there is a need to examine the response in pig performance to incremental levels of oil inclusion compared with the performance of pigs offered cereal-based diets. Therefore, the aim this study was to examine the effects of offering cereal-based diets or diets containing by-products and oil on the growth performance of commercially housed growing pigs.

Materials and methods Seven experimental diets were formulated; A (control diet), B (diet A + 19g/kg oil), C (diet A + 38g/kg oil), D (diet A + 58g/kg oil), E (diet A + 76g/kg oil), F and G. Half of the total amount of oil added to each diet was incorporated into the pellet and the remainder was sprayed on after pelleting. The control diet (A) consisted of g/kg; 250 barley, 160 wheat, 65 maize germ, 50 maize gluten, 50 maize gluten feed, 150 wheat pollard, 75 rapeseed, 163 soya 50, 32 binder, 5 minerals and vitamins. Diet F consisted of g/kg: 456 barley, 250 wheat, 247 soya 50, 42 binder, 5 minerals and vitamins. Diet G consisted of g/kg: 249 barley, 326 wheat, 150 barley, 227 soya 50, 10 herring, 33 binder, 5 minerals and vitamins. Diets F and G were formulated to have equivalent DE values to diets B and D respectively. In total 1540 pigs on a commercial farm in 22 pigs per pen (balanced for gender and weight) were randomly allocated to the seven experimental diets over eight replicated. Pigs were offered the diets between 41kg and 91kg. Feed was offered *ad lib* and performance parameters ADG, daily feed intake (DFI), feed conversion ratio (FCR) and DEI were determined as were carcass measurements (P_2, kill out percentage (KO%) and cold carcass weight). Results were analysed by ANOVA using Genstat 5 (1993) with start weight included as a co-variate.

Results Energy source had a highly significant effect ($P<0.001$) on DFI, FCR, and P_2 value of the carcass and a significant effect ($P<0.05$) on ADG (Table 1). The diet with the highest inclusion of oil (E) resulted in pigs with the lowest DFI and ADG. DEI and ADG were highest for pigs offered the diets which included cereals as the source of energy (F and G). The P_2 values of the carcasses from pigs offered the diets with the highest inclusions of oil (D and E) were higher for diets A-C and similar to those for the cereal diets (F and G). There were no differences in KO% from the different diets. Linear trends corresponding to increasing oil level were significant for DFI, FCR and P_2.

Table 1 Performance parameters and carcass data resulting from different sources of energy

	A	B	C	D	E	F	G	s.e.m.	P
Added oil (g/kg)	0	19	38	57	76	0	0		
ADG (g/d)	866^{ab}	884^{ab}	888^{ab}	884^{ab}	858^{a}	929^{c}	900^{bc}	14.3	P<0.05
DFI (kg/d)	2.35^{d}	2.20^{b}	2.16^{ab}	2.17^{ab}	2.08^{a}	2.30^{cd}	2.21^{bc}	0.033	P<0.001
FCR	2.72^{b}	2.49^{a}	2.44^{a}	2.46^{a}	2.44^{a}	2.48^{a}	2.46^{a}	0.038	P<0.001
DEI (MJ/d actual)	28.9^{ab}	28.1^{a}	28.7^{ab}	29.5^{bc}	28.8^{ab}	30.6^{c}	30.5^{c}	0.44	P<0.001
P2 (mm)	10.1^{a}	10.1^{a}	10.3^{ab}	11.1^{c}	11.1^{c}	10.9^{bc}	11.0^{c}	0.24	P<0.001
KO (%)	73.9	73.5	73.1	73.7	75.2	74.7	75.7	0.74	NS

Means with the same superscript are not significantly different

Conclusions The inclusion of oil with by-products (diets B to E) improved FCR to an equivalent level for diets F and G suggesting that oil addition is effective in improving the energy value of by-product diets. However, pigs offered diets F and G had higher DFI and DEI which may be attributed to the lower levels of fibre or higher palatability when compared with diets B to E. The method of oil application may have reduced the palatability of the oil diets and further research is required to examine the effect of the method of oil addition in the diet on pig performance. Although the DFI differed significantly between the diets of B to E the DEI did not, indicating that at increasing energy levels the pigs were able to regulate intake to satisfy energy requirements which is in keeping with the findings of Weatherup *et al* (2002). However, this is not the case for diets F and G as DFI and DEI of pigs offered these diets were relatively high suggesting that pigs had reached their ceiling for voluntary feed intake of these diets under the commercial situation.

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Effect of dietary phytol levels on the incorporation of phytanic and pristanic acid and the fatty acid composition of pork tissues

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Introduction Phytanic acid (PhA) is a multibranched chain saturated fatty acid (SFA), derived from phytyl, the side chain of chlorophyll. The main sources of PhA in the human food supply are through ruminant products and seafood. The α-oxidation of PhA in the liver results in the formation of pristanic acid (PrA) which is then further fully β-oxidised. This pathway has been extensively studied in relation to genetic defects in the metabolic function of peroxisomes (e.g. Refsum disease) (Verhoeven & Jakobs, 2001). However, as both PhA and PrA induce PPAR-dependent pathways, they have been proposed as functional food compounds to combat, e.g. non-insulin dependent diabetes (Mc Carthy 2001), a disease afflicting a rapidly increasing proportion of the human population. The aim of this experiment was to increase the PrA and PhA levels in pork tissues by supplementing phytol in the diet and to study its effect on fatty acid metabolism.

Materials and methods Sixteen male pigs (Pietrain x Seghers Hybrid) (mean (SD): 82.1 (2.89) kg live weight) were divided into four groups and were fed a standard fattening diet including either 0, 5, 10 or 20 g phytol (BASF, Belgium)/kg feed. The experimental diets were fed for four weeks before slaughter. Animals were slaughtered at a mean live weight of 91.3 (SD 5.29) kg, with a trend towards a lower slaughter weight at higher dietary phytol levels. After cooling of the carcasses for 24 h at 4°C, samples of the *longissimus thoracis* (6-7th rib, left side), lard, liver (small lobe) and heart (left ventricle) were taken, immediately vacuum packed and frozen at –20 °C until fatty acid analysis (Raes et al., 2004). Data were analysed by ANOVA with Duncan as post hoc test (SPSS for Windows, release 11.0).

Results In Table 1 the proportion of SFA, monounsaturated fatty acids (MUFA), n-6 and n-3 polyunsaturated fatty acids (PUFA), PrA and PhA, expressed as g/100g total fatty acids, is given for liver, heart and muscle tissue for the different dietary groups. A dietary supply of 20 g phytol/kg feed resulted in an accumulation of approximately 20 g PhA/100g fatty acids in liver and heart tissue, while only 1.84 g PhA/100g fatty acids was incorporated in muscle. The incorporation of PrA was much lower compared to PhA. Only 1 to 1.5 g PrA/100g fatty acids was found in liver and heart tissue respectively at a 20 g dietary supply of phytol/kg feed. Incorporation of PhA and PrA in liver and heart tissue had distinct effects on the fatty acid profile of the SFA, MUFA and PUFA. Indeed a significantly decreased PUFA proportion was observed with increasing dietary phytol levels in liver and heart tissue. This was reflected in a significantly decreased incorporation of all individual and total n-3 PUFA, whereas the effects on the individual n-6 PUFA was mainly on C20:4n-6. The effects of dietary phytol supply on the SFA and MUFA were less pronounced compared to the effect on the PUFA. Dietary phytol supply had almost no effect on muscle fatty acid composition. Surprisingly, no PhA and PrA could be detected in the lard tissue, regardless of the dietary phytol level, and as a consequence no differences in individual and total SFA, MUFA and PUFA were found between the dietary groups (data not shown). It is obvious that these high levels of PhA in liver and heart tissue following the high dietary phytol levels used in this study may affect the animal metabolism.

Table 1 Effect of dietary phytol supply on the fatty acid composition of muscle, liver and heart tissue (g/100g of total fatty acids)

	Level of dietary phytol (g/kg)					
	0	5	10	20	P	SEM
Liver						
PrA	0.06^{a}	0.31^{ab}	0.58^{bc}	1.00^{c}	0.003	0.11
PhA	0.19^{a}	4.80^{ab}	7.67^{b}	21.6^{c}	0.000	2.21
SFA	38.7^{a}	38.5^{a}	36.9^{a}	28.3^{b}	0.000	1.14
MUFA	21.7	19.0	19.2	18.7	0.311	0.62
n-6 PUFA	32.0^{a}	29.8^{a}	28.3^{a}	22.0^{b}	0.006	1.21
n-3 PUFA	4.76^{a}	4.21^{a}	4.39^{a}	2.72^{b}	0.003	0.25
Heart						
PrA	0.02^{a}	0.03^{ab}	0.37^{bc}	1.51^{c}	0.000	0.17
PhA	0.00^{a}	0.62^{ab}	5.49^{b}	20.4^{c}	0.000	2.27
SFA	30.7	28.9	29.5	26.1	0.537	1.09
MUFA	18.6^{a}	18.8^{a}	14.9^{a}	15.2^{b}	0.020	0.63
n-6 PUFA	38.9^{a}	38.3^{a}	37.7^{a}	28.2^{b}	0.000	1.21
n-3 PUFA	42.5^{a}	41.7^{a}	41.0^{a}	31.0^{b}	0.000	1.29
Muscle						
PrA	ND	ND	ND	0.04		
PhA	0.05^{a}	0.44^{a}	0.78^{a}	1.84^{b}	0.003	0.21
SFA	34.2	36.1	36.1	35.1	0.369	0.43
MUFA	41.9	43.8	44.7	43.3	0.692	0.77
n-6 PUFA	16.2	15.1	13.9	15.4	0.737	0.67
n-3 PUFA	1.24	1.15	1.15	1.22	0.751	0.04

^{a,b,c} Means with different superscripts are significantly different ($P < 0.05$); ND = not detected

Conclusions Distinct effects of dietary phytol supply were observed on the incorporation of PhA and PrA in liver and heart tissue, as well as on their fatty acid composition. Much less pronounced effects were noticed in muscle, and no effects in lard tissue.

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Immunoglobulin, lysozyme, protein and amino-acid content of colostrum of sows fed liquid feed fermented with porcine *Lactobacillus salivarius.*

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Introduction It is essential that the newborn piglet obtains a good intake of colostrum. The internal absorption of colostral antibodies by the piglet's gut is of tremendous importance, as newborns do not synthesise any appreciable level of antibody before the age of 3-4 weeks. Recent UK data showed that an average of 10 % of potential growing pigs die before weaning (Meat and Livestock Commission, 2001). In addition to representing a serious economic impact, these high pre-weaning mortality rates are also unacceptable from an animal welfare viewpoint. A review of the literature shows that there are considerable number of studies, which report the use of various *Lactobacillus* strains as probiotic agents. In addition to their nutritional and antimicrobial effects, many of them have immunomodulatory activity. This study investigated the effects of liquid feed, fermented with porcine *Lactobacillus salivarius*, on the quality of colostrum produced in terms of its mitogenic activity as well as immunoglobulin, protein and lysozyme contents.

Materials and methods A study was conducted according to a randomised block design, with two replicates. Eighteen gilts (Large White x Landrace) were randomly allocated to one of the three dietary treatments namely: fermented liquid feed (FLF), non-fermented liquid feed (NFLF) and dry feed (DF) in pelleted form. *Lactobacillus salivarius* of pig origin was used as a starter culture for FLF. After 24-hours sanitization with chlorine dioxide (Sanitech 2%; Alltech Inc., Kentucky) the feed was inoculated with liquid lactobacillus starter culture to give a final concentration of between 6 and 7 $\log_{10}$ cfu ml^{-1} liquid feed. The inoculated feed was fermented for 36 hours at 30°C. Feeding took place twice a day for a period of 2 weeks before farrowing date, and for 3 weeks after farrowing according to MLC's Stotfold Feeding Scale (1999) for lactating sows. Colostrum samples were collected at parturition by manual milking. The concentrations of IgG, IgA and IgM were determined by sandwich ELISA using commercial ELISA Quantitation Kits (Bethyl Laboratories, Inc., USA). Protein content in defatted colostrum samples was determined by Lowry protein assay. The analysis of amino acids was performed by Amino Acid Analyser (AAA) ion chromatography unit (Dionex Inc, Sunnyvale, CA). Lymphocyte proliferation assay were carried out in triplicate determinations and repeated at least twice. Statistical analyses were undertaken using Minitab v 13.31.

Results The results showed that colostrum from FLF-fed sows contained 48.95mg ml^{-1} of IgG which was significantly higher ($P<0.05$ and $P<0.01$) than colostrum of NFLF (36,62 mg ml^{-1}) and DF-fed (30.81 mg ml^{-1}) gilts respectively (Table 1). A significant difference ($P<0.05$) was also observed in colostral IgA concentration of FLF-fed mothers (15.01 mg ml^{-1}) compared with NFLF (10.57 mg ml^{-1}). There were no significant differences in IgM concentration or protein, amino acid and lysozyme content of the colostral samples (Table 1). Mitogenic experiment showed the significantly better proliferation activity ($P<0.01$) of colostrum samples from the group of sows fed FLF compared with NFLF and DF respectively (Table 1).

Table 1. *Mitogenic activity of gilts' colostrum on pig blood lymphocytes and concentration (mg ml^{-1}) of immunoglobulins G (IgG), A (IgA), M (IgM), total proteins, and lysozyme* (μg ml^{-1}) *in colostrum of sows fed fermented liquid feed (FLF), nonfermented liquid feed (NFLF) and dry feed (DF).*

	IgG	IgA	IgM	Total proteins	Lysozyme	Mitogenic activity
FLF	48.95 ± 3.27^{a}	15.01 ± 1.04^{a}	5.60 ± 0.62	215.8 ± 11.53	13.26 ± 1.30	1319 ± 143^{a}
NFLF	$36.62 \pm 3.50^{b,c}$	10.57 ± 1.11^{b}	4.37 ± 0.66	175.4 ± 12.32	9.66 ± 1.02	745 ± 45.8^{b}
DF	30.81 ± 3.50^{c}	$11.96 \pm 1.11^{a,b}$	5.03 ± 0.66	198.1 ± 12.32	10.09 ± 1.18	867 ± 95.8^{b}

Data are expressed as a mean ± SEM; Data for mitogenic activity are expressed as a mean counts per minute (CPM) ± SEM;
[a,b,c] Within columns, means with a common superscript are not statistically different

Conclusions The immunostimulatory effect of FLF may be due to the presence of high numbers of LAB, namely *Lactobacillus salivarius*. While IgA plays the most important role in mucosal protection, IgG protects piglets against many systemic pathogenic agents. These results suggest that in terms of colostral Ig(s), FLF feeding could have significant health benefits for newborn piglets during this short but critical period after birth. The mechanisms by which this occur remained to be determined. Lymphocytes represent key cellular components responsible for the specificity of the immune system. Immune responses depend not only on the activation of lymphocytes, but also on the ability of lymphocytes to proliferate. Thus colostrum of higher mitogenic activity has the potential to speed up the maturation of newborn's immune system and provides the piglet with better protection.

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Bayesian and REML estimates of heritability of three-times milking complete lactation milk yield in Iranian Holstein heifers

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Introduction Genetic parameters, which are based upon (co) variance components, are necessary elements in dairy cattle genetic evaluation programmes for either productive or reproductive traits that are of economic importance. Recently, there has been an increasingly interest in applying Bayesian-based methods as an alternative over classical linear models such as REML to estimate more accurate genetic parameters of the traits under consideration in animal breeding data (Gianola, 2000). However, as compared to classical methods such as REML, Bayesian estimation of genetic parameters is theoretically more complex and also needs much more computational time that could be a potential a limiting factor in practical application of the Bayesian methods. In this study the main objective is to estimate of heritability of complete lactation milk yield of Iranian Holstein heifers with the use of Bayesian (based on Gibbs Sampling that is a Monte Carlo method) and REML (based on Analytical Gradients technique) approaches.

Material and Methods The total data consisted of 17,946 complete lactation (completed lactations was defined as 270<=DIM<=300) milk yield records obtained from 17,946 Iranian Holstein heifers (with three times milking a day) calved between 1986 and 2001 and distributed in 286 herds of Iran. The description of the data set is given in Table 1. A univariate animal model was used to estimate variance components of additive genetic and residual effects. In the animal model, fixed effect of contemporary groups of Herd-Year-Season of calving $(HYS)_i$ **,** linear and quadratic (non-orthogonal) covariates of age (in month) of cow at calving (A_{ij}), linear and quadratic (non-orthogonal) covariates of days in milk (DIM_{ij}), random effect of additive genetic (a_j) were fitted for milk yield (MY_{ij}) of the j^{th} cow in the i^{th} contemporary group. Analyses were conducted using VCE (Variance Component Estimation) programme (Groeneveld, 1998) to obtain Bayesian and REML estimates of variance components based on MCMC (via Gibbs sampling technique with a long chain of 80,000 samples) and Analytical Gradients techniques respectively. The mathematical model was as follows:

$$MY_{ij} = (HYS)_i + [\sum_{R=1}^{2} \beta_R * (A_{ij})^R] + [\sum_{R=1}^{2} \gamma_R * (DIM_{ij})^R] + a_j + e_{ij}$$

Table 1 Description and characteristics of data set used for Bayesian and REML analyses

Data set	*Records*	*Cows*	*Dams*	*Sires*	*Herds*	*Years*	*HYS*
First Complete Lactation	17,946	17,946	16,003	882	286	16	2,469

Results REML and Bayesian estimates of additive genetic (σ_a^2) and residual (σ_e^2) variance components as well as heritability (in narrow sense) of complete lactation milk yield are presented in Table 2. Although as compared to REML method a greater additive genetic and a lower residual variance component were obtained in Bayesian approach, no meaningful difference between heritability estimates was revealed between two methods of estimation. The heritability estimate of complete lactation milk yield in Iranian Holstein heifers was found to be in the range of heritability estimates obtained for Holstein populations (Lobo *et al.*, 2000) by other previous research workers.

Table 2 REML and Bayesian estimates of variance components and heritability of complete lactation milk yield

Method of estimation	*Additive genetic*	*Residual*	*Heritability*	*SE of Heritability*
REML (by Analytical Gradients)	350625	850131	**0.292**	0.020
Bayesian (by Gibbs Sampling)	357280	845828	**0.297**	0.020

Conclusion In this study REML and Bayesian estimates of heritability of three-times milking complete lactation milk yield in Iranian Holstein heifers were found to be approximately the same suggesting that the former could be used where computational time is a limiting factor in a national scale genetic evaluation programme. At present study univariate analysis based on lactation milk trait was carried out. However since multiple-trait genetic evaluation of dairy cattle is usually practised, further research is needed to compare multivariate Bayesian and REML estimates of genetic parameters including genetic and environmental correlations as well as heritabilities of the traits under consideration.

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Genetic and environmental influences on live weights of Japanese quail.

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Introduction Maternal effects are important in mammals and include genetic and environmental influences. They are also known in birds, particularly in the context of behaviour. The current investigation examined the maternal influences on weights of Japanese Quail, reflecting residual effects in a situation where chicks were artificially incubated and reared.

Materials and Methods The Japanese quail population (n=1703) used for the present study was described in detail by Saatci et al. (2003). It consisted of individually recorded birds, weighed weekly from hatching to 6 weeks of age. The identity of the male and female parents of each bird was recorded with 6.4 and 5.6 progeny per sire and dam respectively. The initial model fitted for each trait included bird as a random factor to fit the additive direct effect, an additive maternal effect, the maternal permanent environment effect, and a covariance between direct and maternal genetic effects. The most appropriate model was determined by eliminating terms in a step-down procedure and comparing models by a likelihood ratio test. The best model for each trait was compared to one in which a maternal common environment effect was also included. This term represented an environmental effect associated with dams within incubation batches and is considered to be comparable to litter effects fitted for sheep data. Whether variance components were significantly different to zero was determined by the procedure described by Gilmour *et al.* (1998).

Results Mean weight was 8g at hatching and increased from 20g to 177g in weeks 1and 7 respectively. The covariance between direct and maternal effects was not significant ($P>0.05$) for any of the traits and the dam permanent effect was significant ($P<0.05$) only for weight at hatching. Direct heritability was not significant at hatching and ranged from 0.15-0.18 for the other weights. The maternal heritability was highest at hatching and tended to decrease with time. Including the common environmental effect improved the fit of all models ($P<0.05$) but also decreased the estimates of h^2 and m^2. The estimate of the common environmental effect was 0.26 at hatching and ranged from 0.13-0.16 for other weights.

Table 1 Estimates of genetic parameters in models excluding a maternal common environmental

	Hatching	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	SE range
h^2	0.05 *	0.15	0.13	0.16	0.18	0.15	0.18	0.033-0.053
m^2	0.25	0.18	0.11	0.10	0.09	0.10	0.05	0.024-0.081
pe^2	0.18							0.067
e^2	0.52	0.67	0.76	0.75	0.73	0.75	0.77	0.039-0.048

Table 2 Estimates of genetic parameters in models including a maternal common environmental variance

	Hatching	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	SE range
h^2	0.01 *	0.12	0.11	0.12	0.14	0.11	0.16	0.032-0.053
m^2	0.28	0.12	0.06	0.06	0.05	0.07	0.03 *	0.023-0.080
pe^2	0.10							0.063
ce^2	0.26	0.16	0.15	0.16	0.16	0.16	0.13	0.031-0.036
e^2	0.35	0.59	0.67	0.66	0.65	0.66	0.68	0.030-0.047

h^2 direct heritability; m^2 maternal heritability; pe^2 maternal permanent environmental effect; ce^2 maternal common environmental effect. * Component not significantly different to zero ($P>0.05$)

Conclusions The results show the importance of maternal influences on the early weights of Japanese Quail. Since there is no physical association between a bird and its dam during incubation or early growth it can be assumed that the maternal effects, both genetic and environmental, are residual effects associated with characteristics of the egg at laying (Catterall, and Pollott, 1996). Permanent environmental effects of dam influenced only hatching weight, suggesting that those permanent characteristics of the dam that are the result of environment are unimportant for weights after hatching. The data structure did not allow satisfactory partitioning of the error variance since including a common environmental effect in the model also affected the estimates of genetic parameters. A rough estimate (comparing e^2 for the models with and without ce^2) suggests that the common environment effect is about 0.17 at hatching and in the range 0.07-0.10 for other weights.

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Estimation of phenotypic and genetic correlations between production traits and herd life in Iranian Holstein heifers

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Introduction In practical dairy cattle breeding programmes many traits of major economic importance such as milk yield, type and herd life (longevity) are usually included in genetic evaluation systems. Herd life, as a complex trait associated with longevity of animals, has been long considered to be related to profitability of dairy herds due to increase the proportion of more mature, higher yielding cows in the herds, increase the opportunity for voluntary culling, reduce replacement costs and increase the proportion of farm resources used for the milking herd rather than for replacements (Brotherstone *et al*., 1998). In fact, as pointed out by Burnside *et al*. (1984), lifetime profitability is affected by many factors such as production per lactation, length of productive life, age at first calving, calving interval as well as input and output prices. The main aim of the present study is to estimate phenotypic and genetic correlations between production traits (milk yield and fat percentage) and herd life (defined as the interval between first calving and culling dates) in Iranian Holstein heifers.

Material and methods In this study, a total of 39310 lactation milk yield, fat percentage and herdlife records obtained from 39310 Iranian Holstein heifers calved between 1991 and 1999 and distributed in 260 herds of Iran was used. Herd life was defined as the interval between first calving date and culling date. A tri-variate animal model was utilised to estimate variance components of additive genetic and residual effects for the corresponding traits. In the animal model, fixed effect of contemporary groups of Herd-Year-Season Of Calving $(HYSOC)_{it}$ **,** linear and quadratic covariates of Age at first calving of cow (A_{ij}), linear and quadratic covariates of Holstein Gene Percentage (HGP_{ij}), random effect of additive genetic (a_{jt}) were fitted for all traits (Y_{ijt}) including milk yield, fat percentage as well as herd life . Analyses were undertaken using DFREML programme to obtain REML estimates of variance components based on Powell search technique. The mathematical model was as follows:

$$Y_{ijt} = \mu + (HYSOC)_{it} + \sum_{R=1}^{2} \beta_R * (A_{ij} - \overline{A})^R + \sum_{R=1}^{2} \gamma_R * (HGP_{ij} - \overline{HGP})^R + a_{jt} + e_{ijt}$$

Results Multivariate REML estimates of heritability (in narrow sense) of complete lactation milk yield, fat percentage and herd life as well as genetic and phenotypic correlation among these traits are presented in Table 1. As is shown in the table, genetic correlations between milk yield and fat percentage (in absolute term) and between milk yield and herd life were generally greater than that of corresponding phenotypic correlations. The genetic and phenotypic correlations found between fat percentage and herd life followed the same pattern. In general, the heritability estimate of the production traits considered in Iranian Holstein heifers was in the range of average estimates of genetic parameters reported by Lobo *et al*. (2000).

Table 1 Heritability, genetic (lower diagonal) and phenotypic correlations (upper diagonal) among the traits

Trait	*Milk yield*	*Fat percentage*	*Herd life*
Milk yield	**0.25**	-0.53	+0.33
Fat percentage	-0.80	**0.29**	-0.19
Herd life	+0.97	-0.63	**0.002**

Conclusion In this study REML estimates of heritability of complete lactation milk yield, fat percentage in Iranian Holstein heifers were found to be moderate suggesting that these traits could be improved through selection of animals with a higher potential for milk yield as well as fat percentage over the lactation course. In accordance with other previous research such as Brotherstone *et al*. (1998), the heritability estimate obtained in the present study for herd life was very low. With respect to low heritability of herd life, which indicates greater environmental variation as compared to genetic variation, a significant genetic improvement in this trait could not be made through selecting animals with higher performance for herdlife. However, a very high positive genetic correlation found between milk yield and herd life indicating that correlated response for herd life could be expected when direct selection is practiced on milk yield.

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Study of genetic and environment trends for milk production traits in an Iranian dairy herd

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Introduction In order to evaluating genetic improvement in a selected population, variation resulted from environment and genetic should be dissociated. Because of positive genetic correlation between milk production and fat and protein yield, selection for milk production often resulted in an increase in fat and protein yields however response for fat percentage is negative. However positive genetic trends between 26 to 173 Kg in a year for milk production in Holstein Cattle are reported in some studies that milk yield had less importance in selection index, also negative values are reported. Based on previous researches, genetic improvement of milk yield up to 1 percent due to selection is possible and from theoretical view, an improvement about 2 percent is reported. With attention to performed selection in the herd and using progeny tested sperms from foreign countries that have suitable genetic potential, this study was accomplished in order to estimating genetic parameters of milk production trait and investigating genetic and environment trends during 1990 until 2001.

Materials and methods Data of pedigree and milk yield trait of a Holstein herd was used. This data set included first and second lactation records, which collected during 1990-2001 by Khorasan Animal Breeding Center. This data set was obtained from 114 and 801 sires and their daughters respectively. The records were corrected based on 305 days of lactation and twice milking. For prediction of genetic parameters, two models were used: the univariate model was applied to first lactation records and the repeatability model was applied to first and second lactation records. (Co)Variance components were estimated for milk yield, using an animal model and Restricted Maximum Likelihood Method based on a Derivative-Free algorithm. Variance components and genetic parameters were estimated by DF-REML software. Obtained models are:

$$y_{ijkl} = \mu + (YS)_i + b_1 D_{jk} + b_2 D_{jk}^2 + b_3 D_{jk}^3 + a_j + e_{ijkl}$$

$$y_{ijkl} = \mu + (YS)_i + b_1 D_{jk} + b_2 D_{jk}^2 + b_3 D_{jk}^3 + a_j + p_i + e_{ijkl}$$

$y_{ijkl} = Observation \quad \mu = Trait\ mean$

$(YS)_i = Effect\ of\ year-season(\ fixed\ ) \qquad D_{jk} = K\ age\ group\ of\ j\ animal(covariate\ )$

$b_1, b_2, b_3 = Linea, Quardratic, \qquad regression\ coefficient\ of\ gstation\ age$

$a_j = Genetic\ effect\ of\ j\ animal(\ Random\ )$

$e_{ijkl} = Residual(\ Random\ )$

Genetic trend of milk production was estimated using regressing average of breeding values (BV) on gestation year (in sires, on gestation year of their daughters).

Results Obtained results of genetic trend estimation by two noted models were the same. Estimated genetic trend for milk yield of sires and cows were –13.89±8.54 (b±CV) and –6.90± 4.71 Kg respectively. Mean of milk yield in cows in noted date increased by 271.85 ± 23.11 Kg per year and estimated environmental trend of milk yield in cows was 278.33 Kg per year that displays the improvement in management and environmental condition in different years.

Conclusions The results indicate that selection and mating in the herd were only based on phenotype, not BV. It must be noted that the sperms from other countries (The USA and Canada) were used, so factors such as interaction between genotype and environment can reduce genetic improvement. In other words, because of interaction between genotype and environment, animals that are superior in an environment possibly may not be superior in other environments and may have less performance

Figure1 Stimated Genetic Trend for mike Yield(kg)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Sires (kg)	-32.298	-24.303	-9.258	63.007	239.254	149.819	-63.057	-93.039	-143.62	-121.03	-53.986	-168.51
Cows (kg)	47.697	-4.032	-12.242	99.635	123.413	58.723	-31.228	-39.855	-43.176	-21.047	56.19	-95.142

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Application of DNA amplification for genotyping cattle from milk

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Introduction Blood is a good source of DNA, although other tissues such as skin biopsies or hair follicles can be used (Heal et al, 2002). Milk, which is widely available and obtained non-invasively, would be the source of choice in lactating animals. However, it is difficult to extract DNA from small samples of milk in quantities sufficient for simultaneous genotyping at multiple loci. The objective of this study was to determine whether genomic DNA isolated from small amounts of milk could be amplified to provide sufficient material for running multiple genotyping reactions.

Methods Somatic cells contained in 25 ml of milk were used for DNA isolation using the GeneElute Mammalian Genomic DNA Miniprep Kit (Sigma), Gentra's Genomic DNA Purification Kit (Gentra, Minnesota, USA) or phenol/chloroform extraction. These techniques were compared with a crude DNA isolation method carried out according to the GenomiPhi Amplification Kit (Amersham Biosciences), followed by representative whole genome amplification. DNA was quantified using A260 absorption or fluorescence assay and visualised on agarose/ethidium bromide gels. Genomic DNA from milk was used to amplify a region of the ZFY/ZFX (zinc-finger protein) genes present on the sex chromosomes of placental mammals (Aasen and Medrano, 1990) and the cattle microsatellite marker MGTG13B (605) on chromosome 15 (Kappes et al.,1997). The ZFY/ZFX primers, forward: [ATA ACC ACC TGG AGA GCC ACA AGC T] and reverse: [GCA CTT CTT TGG TAT CTG AGA AAG T] were subjected to 35 cycles of 94^{o}C denaturation, 66^{o}C annealing and 72^{o}C elongation, with 1 µl of amplified genomic DNA as a template and Taq DNA polymerase (DynaZyme). The 455 bp PCR product was analysed on 1% agarose gels and photographed under UV light. The microsatellite locus had an allele size of 133 to 141 bp. The forward primer: [GAG TGA CTC ACT TTC ACC TAT AAT A] and reverse primer: [CTT AGC ATA ACG TCC TCA AGA TTC A] were annealed at 58^{o}C, amplified in a standard PCR reaction for 35 cycles and visualised on polyacrylamide gels.

Results Without amplification, quantities of DNA obtained were low and variable. Yields of genomic DNA extracted from cells prepared centrifugally from stored cow's milk ranged from 0 – 83 % of the level expected on the basis of somatic cell counts. The GenomiPhi Amplification Kit utilising Phi29 DNA polymerase with random hexamer primers was used with 12 random milk samples containing numbers of somatic cells in the range 11 x10^{3} to 194 x10^{3}. All samples acted as PCR templates for both sequences analysed (Fig. 1 and Fig. 2). Controls without DNA were negative (data not shown).

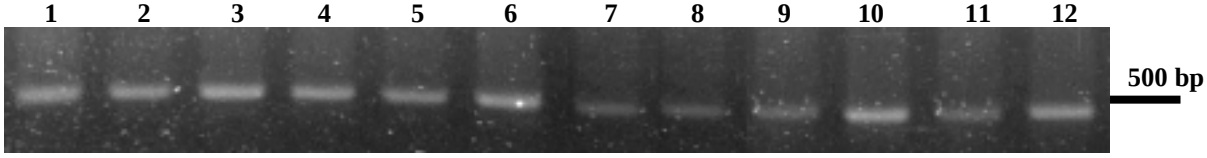

Figure 1 PCR amplification of ZFY/ZFX fragment of 455 bp from 12 milk samples, electrophoresis on 1% agarose.

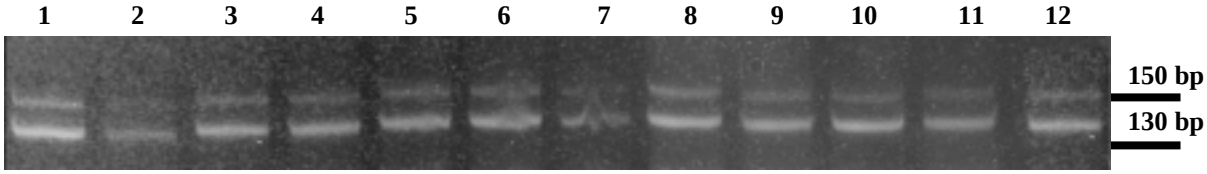

Figure 2 The same DNA from 12 milk samples used in PCR amplification of cattle microsatellite marker MGTG13B (605) on 15 % polyacrylamide.

Conclusions Although milk contains somatic cells usable as a source of genomic DNA, the amount of DNA obtained is frequently low and variable, even if the somatic cell count is known. These difficulties can be overcome by amplification, which produces µg amounts of copied genomic DNA for use in downstream applications from traces of DNA extracted from small quantities of milk.

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Performance of an endangered fowl under backyard system – An inventory

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Introduction Nicobari fowl is an endangered breed of chicken with an estimated population of 7524 (Chatterjee and Yadav, 2003). This breed is endemic to Andaman and Nicobar Islands and are distributed in a scattered form. Andaman and Nicobar group of Islands are located in the Bay of Bengal (Latitude $6^0 45^/$ N and $13^0 41^/$ N, longitude $92^0 12^/$ E and $93^0 57^/$E) and have a typical maritime climate. The bird is brownish matty in colour, medium in size, short-legged and hardy with compact body conformity. The bird has short and thick neck, black plumage tipped with brown shade, breast bulging in front, medium sized tail and long saddle feathers (Chatterjee et al., 2003). The present study was an effort to characterize the growth, production and reproductive performance of the breed under backyard system in Middle Andaman, India.

Materials and methods A total of 326 Nicobari fowl from 21 villages were studied for evaluation of the breed under backyard management system in Middle Andaman, India. The survey work was done in the selected villages by a standard proforma of NBAGR, Karnal, India. A total of 62 farmers of 21 villages (having Nicobari fowl) were included in the survey work. Under backyard system, the birds are fed with supplementary feed like kitchen wastes, rice, wheat, coconut grating etc. and the birds are allowed to go to forest for free ranging. The amount of feed provided by the farmers varied from 12-25 g/day/bird. Vaccination was not administered for any disease. Information was collected on flock size, number of persons engaged in poultry, total family members, body weights of the birds at 2 weeks interval up to 12 weeks of age, age (ASM) and weight at first egg (WAM), first hundred (EP100) days and annual egg production, egg weight, hatchability and mortality in laying period. Mean and standard errors were calculated by standard statistical package.

Results The population size of Nicobari fowl was estimated as 1079 in Middle Andaman. The average total poultry flock size per family was 22.7 (± 2.2), which included Nicobari, Naked neck, Frizzle fowl, non descript fowl and ducks, however, the flock size of Nicobari was 5.3 (± 0.9) per family. But, all the farmers in the villages did not have the Nicobari fowl. Only a few farmers of the studied villages were having the bird. The average number of persons engaged in poultry and total number of members in the family were 1.2 (± 0.12) and 5.8 (± 0.4), respectively. The body weights of young chicks at different ages were lower. The birds started egg production at 196 days of age with an average body weight (pooled for male and female) of 896.7 g. Average annual egg production was 137 in number, which is highest among all the indigenous breeds of India under back yard farming. The egg size was lower (40.2 g) than commercial chicken breed. The hatchability under natural incubation and mortality in laying period were moderate (Table 1). Average daily feed consumption (which included all age groups of birds) and cost of feed were very low.

Table 1 Performance of growth and production traits of Nicobari fowl under backyard system

Growth Traits	Mean ± SE (sample size)	Production Traits	Mean ± SE (sample size)
BW – DO (g)	31.7 ± 2.2 (119)	ASM (days)	195.7 ± 3.8 (205)
BW-2 (g)	102.0 ± 6.5 (159)	EP100 (in no.)	37.2 ± 1.0 (131)
BW-4 (g)	143.8 ± 7.4 (191)	Annual egg production (in no.)	137.0 ± 3.5 (163)
BW-6 (g)	210.9 ± 9.5 (210)	Egg weight (g)	40.2 ± 0.5 (135)
BW-8 (g)	304.9 ± 22.4 (204)	Hatchability (%)	69.6 ± 2.9 (135)
BW-10 (g)	370.9 ± 12.4 (214)	Mortality in laying period (%)	6.3 ± 0.3 (178)
BW-12 (g)	433.6 ± 8.7 (206)	AFC/day/bird (g)	14.7 ± 0.8 (126)
WAM (g)	896.7 ± 7.7 (201)	Cost of feed/day/bird (Rupee)	0.12 ± 0.02

Where, BW –DO, BW-2, BW-4, BW-6, BW-8, BW-10, BW-12, denote body weight at day old, 2,4,6,8,10 and 12 weeks of age, respectively.

Conclusions The results of the study suggest that under backyard system the body weights of the young chicks and average egg weight of this endangered breed were lower. However, annual egg production was higher and mortality of the breed was moderate under village condition with lesser feeding, management and without vaccination.

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The relationship between defensin genes polymorphism and milk somatic cell score, milk production, milk composition and reproductive traits in Holstein cows.

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Introduction Antimicrobial peptides represent an abundant of innate immunity with over 300 different protein sequences described in species ranging from insects to mammals (Boman, 1995). One group of such peptides, due to its antibiotic and cytotoxic activity against bacteria, viruses and fungi was called defensins. Expressions of ß-defensin genes were shown in the cow's mammary gland and in famale urogenital tract (Ryniewicz etal. 2002). Cattle defensin genes have been localized on chromosome 27. Because defensin peptides protect animals against bacterial, viral and fungal infections, the genes encoding these peptides seem to be potential markers in studies on the genetically determined resistance (or susceptibility) of the mammary gland and also on the reproductive rate. This experiment was conducted to study the presence and comparing the frequencies of various alleles of defensin genes in cows differing in udder health statuses and in some reproductive traits.

Material and methods The study was conducted on 103 dairy Holstein cows. The cows were born between 1990 and 1995. The analyzed data were days open (OD), Services per conception (SPC), Body Condition Score (BCS), calving interval (CI), age at the first mating (AFM), monthly milk recording, and the percentage of fat, protein and lactose in sampled milk. Simultaneously somatic cell count was determined in milk samples and treated as an indicator of udder health status. Before data analysis, we transformed somatic cell count to data somatic cell score (SCS). Genomic DNA was extracted from 100µl blood sample according to Boom et al (1990). Gel monitoring method was used for determination DNA quality and quantity. The amplification of defensin gene fragments, from 1650 to 1300 bp, was performed by BBD-1S and BBD-2A Primers (Ryniewicz etal. 2002). The quality of the PCR products was tested electrophoretically in 1% agrose gel with ethidium bromide. In order to enzymatic restriction of amplified DNA fragments *Tag I* enzyme was used. Digested products were separated by electrophoresis on 3.5% polyacrilamid gel and were visualized after staining with ethidium bromide on gel documentation. In order to determine the significance of the relationship between the polymorphism of defensin genes and somatic cell score, milk production, milk composition and reproductive traits an analysis of variance was performed according to the GLM method. The comparison of somatic cell count means for each genotype was performed by LSD method.

Result In acrilamid gel, as the result of RFLP and analysis of PCR products with *Tag I*, thirteen polymorphic patterns were obtained with frequency of 35.92, 14.56, 9.7, 8.73, 7.76, 5.82, 4.85, 3.88, 2.91, 2.91, .97, .97, and .97.The most frequent genotypes belong to $A_1A_2B_1B_2C_1C_2$ and $A_1A_1B_1B_1C_1C_1$ respectively. The comparison of somatic cell count means showed that the genotype of $A_1A_1B_1B_2C_1C_1$ was significantly different from the other genotypes ($P<0.01$). An initial statistical analysis of obtained results indicates that defensin genotypes may have a significant effect on somatic cell score. The amounts of "F value" related to milk yield, milk composition, SCS and reproductive traits are given in table 1.

Table 1 The amounts of (F value) related to effect of factors analyzed on milk composition, SCS and reproductive traits

Factor	Milk yield (Kg)	Milk fat (%)	Milk protein (%)	Milk lactose (%)	SCS	SPC (%)	AFM (Day)	BCS	CI (Day)	OD (Day)
Genotypes	0.9^{ns}	1.5^{ns}	1.1^{ns}	1.3^{ns}	2.8**	1.4^{ns}	1.3^{ns}	0.6^{ns}	0.4^{ns}	0.5^{ns}
Lactation no	2.1^{ns}	0.6^{ns}	3.2*	0.9^{ns}	1.1^{ns}	2.6^{ns}	0.3^{ns}	0.7^{ns}	1.1^{ns}	6.1***
Birth year	0.9^{ns}	1.1^{ns}	0.6^{ns}	2.8*	1.2^{ns}	1.1^{ns}	4.2*	1.7^{ns}	5.1***	2.4^{ns}
Birth year × Lactation no	1.5^{ns}	0.8^{ns}	0.8^{ns}	2.1^{ns}	0.9^{ns}	1.9^{ns}	0.4^{ns}	1.5^{ns}	0.2^{ns}	0.5^{ns}
Birth year × Genotypes	0.9^{ns}	1.6^{ns}	1.9*	1.7^{ns}	1.2^{ns}	2.1*	1.5^{ns}	0.7^{ns}	0.5^{ns}	1.7^{ns}
S.E.M	0.67	0.065	0.027	0.026	0.0012	0.03	5.21	0.03	12.8	8.9

* P<0.05; ** P < 0.01, ***P<0.001.

Conclusions According to the results it seems that somatic cell count may have an important effect on cattle breeding, and in the other hand it has been known that somatic cells reflect the health status of the mammary gland, so the observed polymorphism in defensin genes and its significant effect on somatic cell score may be lead to the use of defensins as genetic markers of mastitis in the future. Also results of this study indicated that there is no significantly relationship between defensin polymorphism patterns and reproductive traits. However, more comprehensive experiments with large number of cows and much data are needed.

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Identification of bovine kappa-casein genotypes in Iranian Holstein cows by PCR-RFLP

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Introduction The kappa-casein gene has been extensively studied in cattle for its stabilizing role of the casein micelles and, therefore, its influence on the manufacturing properties of milk. In Holstein dairy cattle the B variant of kappa-casein (CSN3) is associated with a higher protein content, better quality of crud and increased yield of cheese. It has been suggested that identification of CSN3 genotypes could be an economically important selection criterion for dairy herds designated for industrial milk production (Pederson, J. 1991). Genotyping of milk proteins, such as CSN3, can be performed by electrophoresis, directly from milk samples, as the expression of the caseins occurs only during the lactation phase in mammary gland cells. Therefore, the use of electrophoresis for genotyping of milk proteins is strongly limited because it can only be used in cows in the lactation stage. With newly developed techniques based on DNA analysis, which include polymerase chain reaction and restriction fragment length polymorphisms (PCR-RFLP) methods, it is now possible to determine the CSN3 genotype of all individuals in a given population under selection, regardless of sex, age or physiological stage (Lara, M.A.C. et al. 2002).The Kappa-casein genotypes has not been detected so far in Sistani cows.

Materials and Methods Samples (89 samples) were supplied from two Holstein dairy cattle located at Mashhad. For each sample 2-5 ml of blood was collected in tubes containing 0.5-1 ml EDTA 10% as anticuagulant. Genomic DNA was extracted from 100 microlitere of blood according to Boom et al.(1998). A fragment of 228 bp from exon IV of CSN3 gene was amplified using 100 ng of genomic DNA in a PCR buffer solution containing 10 pmol of each primer (forward, 5'-TATCATTTATGGCCATTCCACCA-3'; reverse, 5'-CTTCTTTGATGTCTCCTTAGAGTT-3'), 2 mM of MgCl2, 250 uM of each dNTPs and 2 U of Taq start antibody in a total volume of 25 ul. Samples were denatured at 94 ؛C for 2 min. and then were subjected to 35 cycles of 94 ؛C for 1 min., 56 ؛C for 1 min. and 72 ؛C for 1.5 min. with a final extension step of 72 °C for 5 min. PCR products were electrophoresed on a 1.5% horizontal agarose gel containing 0.5 ug/ml of ethidium bromide and photographed under UV light. Five microliters of the PCR products was digested with 5 U each of *Hinf*I (recognition site, 5'-GANTC-3') and *Hind*III (recognition site, 5'-GGCC-3') in two separate reactions. samples were incubated at 37 °C for 3h. The visualization of digestion products was in 8% nondenaturing polyacrylamide gel and staining with ethidium bromide solution. The frequency of genotypes in co-dominant locus was calculated by directly adding the genotype number. PopGen32 software (ver. 1.31) was used to estimating the alleles and genotypes frequencies, Nei's heterozygosity value and X^2 test.

Results Identification of A and B alleles of CSN3 was performed by amplification of a DNA fragment of 228 bp, located in exon IV, by PCR-RFLP method. The DNA fragment amplified from allele A has no any restriction site for HindIII and remains undigested. Allele B was characterized by the presence of two fragments, corresponding to 135 and 95 bp. Genotypic frequencies were 19% for AA, 65% AB and 16% BB. Frequencies of alleles A and B were 52% and 48% respectively. The Nei's heterozygosity value of CSN3 locus was 0.49 (Table 1).The results showed that the frequency of B allele in Iranian Holstein cows is high. Therefore, there is a probability of selecting better quality for high protein content and cheese yield.

Table 1. Gene and genotypic frequencies, Nei's heterozygosity and X^2 test results.

No.	Frequencies					Nei's value	X^2
	A	B	AA	AB	BB		
89	0.52	0.48	0.19	0.65	0.16	0.49	7.96*

* Significant value ($P \leq 0.05$).

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Genotype by nutritional environment interactions for lamb growth and carcass composition

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Introduction Since UK slaughter generation lambs are produced from many different breeds in a wide range of environments, the possibility of interactions between genotype and feed treatment is of both practical and theoretical interest. Such an interaction exists for growth rate in different selection lines of Suffolk sheep on different levels of concentrate feeding (Lewis *et al*., 2002). Whether interactions exist between breed and feed treatment for lamb growth and carcass composition was investigated using two diverse breeds in several different nutritional environments.

Methods In four years, lambs of two breeds [85 Scottish Blackface (B), 88 Suffolk (S)] were grown to a target weaning weight. This was 0.20 of estimated mature weight in years 1 and 2 and 0.30 of estimated mature weight in years 3 and 4, or 8 weeks of age, whichever came sooner. At weaning, lambs were assigned randomly to one of two feed treatments, which differed across years. The pairs of feed treatments used in the different years are shown in Table 1.

Table 1 Feed treatments used in each year of trial

	Nutritional environment	
Year	Better	Poorer
1	high quality concentrate *ad libitum*	bulky concentrate *ad libitum*
2	dried, pelleted lucerne *ad libitum*	dried, pelleted ryegrass *ad libitum*
3 & 4	grazing a clover sward	grazing a ryegrass sward

In years 1 and 2 lambs were housed indoors in individual pens. In years 3 and 4 lambs grazed the allocated sward. Live weights were recorded weekly. On reaching 0.30 and 0.45 of their estimated mature weight, lambs were scanned using X-ray computed tomography (CT) from which their carcass fat, muscle and bone contents (g/kg) were estimated. Average daily gain in live weight (ADG g/day) was calculated between 0.30 and 0.45 of estimated mature weight. The data were analysed separately for each year using general linear models (GLM), including breed, feed and their interaction as fixed effects (Genstat 5, 2001). The data for years 3 and 4 were combined. Sex and other fixed effects were included where appropriate.

Results The results are shown in Table 2. Within year breed by feed interactions for ADG were found for lambs on different quality concentrate feeds and lambs grazing different fresh forages ($P<0.05$). Carcass fat content showed a breed by feed interaction ($P<0.05$) only for lambs on different quality concentrate feeds. Carcass lean and bone contents showed no breed by feed interactions on any of the feeding treatments used. Over all feed treatments, there was a greater distinction between breeds in ADG on feeds that allowed high growth rates than on feeds that limited growth rates. In contrast, breed differences for carcass composition were smaller on feeds that enabled higher growth rate than on feeds that limited growth rate.

Table 2 Least squares means of average daily live weight gain (g/day) and carcass fat content at 0.45 of mature weight (g/kg) for Blackface and Suffolk lambs in different nutritional environments

		Average daily gain (g/day)				Carcass fat content (g/kg)			
		Nutritional environment				Nutritional environment			
Year	Breed	Better	Poorer	s.e.d.	GxE	Better	Poorer	s.e.d.	GxE
1	S	410	311	*35.2*	*	276	244	*11.1*	*
	B	305	265			290	234		
2	S	343	285	*16.3*	ns	248	256	*15.2*	ns
	B	232	198			216	232		
3 & 4	S	215	93	*12.6*	*	206	198	*10.2*	ns
	B	167	93			149	141		

Conclusions Breed by feed interactions existed for lamb growth rate within year; across years S exceeded B by between 0 and 111 g/day. The carcass fat content interaction was such that S had between 16 g/kg less fat and 57 g/kg more fat than B in the carcass. Genotype by environment interactions were important for both growth rate and carcass composition.

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Genetic resistance to scrapie in a flock of Welsh Mountain Sheep

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Introduction There is considerable interest in the eradication of all transmissible spongiform encephalopathies (TSE's) in food producing animals, to minimise any possible risk to human health. Scrapie, a TSE and a notifiable disease, is a fatal neuro-degenerative disease of sheep and goats. Susceptibility is strongly linked to the prion protein (PrP) genotype on three codons 136, 154 and 171. The ARR alleles confer the greatest resistance to disease; ARQ and ARH are intermediates, whereas VRQ confers greatest susceptibility. UK and EU eradication policies are presently selecting for resistance to scrapie and farmers are taking advantage of genotyping schemes to position themselves better in the market place should scrapie resistance become a major market requirement. The objectives of the study were to find out PrP genotypic frequencies and thus PrP gene-associated susceptibility to scrapie in a flock of Welsh mountain sheep and to predict changes in scrapie genotypes as a result to selection.

Materials and Methods Blood samples were collected by animal health officers from 449 Welsh Mountain Sheep (268 breeding ewes and 181 lambs born in 2001 and 2002) from the CAMDA nucleus flock, genotyped through the National Scrapie Plan Scheme (NSP). The animals genotyped were potential replacement animals rather than animals of the whole flock. Each animal had a bolus inserted to provide a NSP electronic identification number. Other information that was recorded included identification provided by the owner, sex, and age group at time of test. Distributions of the genotypes and gene frequencies were calculated for the different sub-groups (grouping based on sex, age group and year of birth) and allocated into risk groups designated by the NSP (DEFRA, 2003). Emphasis placed when selecting rams in the autumn of 2001 was on choosing rams from resistant genotype groups. Of the 8 rams used 6 were in NSP risk group 1 or 2.

Results A total of 10 genotypes out of 15, falling into all five groups designated by the National Scrapie Plan, were found. Overall the most common genotype was AHQ/ARQ (24.5%) and the least common was VRQ/VRQ (0.7%). Four allelic variants occurred in the CAMDA flock, these were ARQ (34.7%), AHQ (31.9%), ARR (20.7%) and VRQ (12.7%). The ARR allele occurred in about 35.3 % of animals. The genotype associated with full resistance, ARR homozygous, was found in 5.3% of total sheep examined and therefore at low risk to scrapie, 22.9% were AHQ/ARR and ARQ/ARR heterozygotes, also with some resistance in individual sheep. However, 7.1% of the ARR heterozygotes were ARR/VRQ, which are in the low resistant group. There was an increase in the number of animals in the more resistant genotypes in the lambs born in 2002 compared with lambs born the previous year. Proportions of scrapie susceptible genotypes (Groups 4 & 5) were present in 25.2% and 2.6% of the lambs born in 2001 and 2002 respectively and are shown in Table 1. The genotype associated to highest susceptibility (VRQ/VRQ) was only found in 2001 lambs.

Table 1. Frequency distribution of sheep into scrapie risk categories

Risk Type (NSP)	Overall data %	Adult Females %	2001 lambs %	2002 lambs %
1	5.3	5.2	2.8	15.8
2	22.9	22.0	14.7	60.5
3	47.0	45.1	57.3	21.1
4	7.1	8.2	6.3	2.6
5	17.5	19.4	18.9	0.0

Conclusions The results show a response to selection by an increase in the proportion of animals with genotypes higher in resistance to scrapie in lambs born in 2002 compared with 2001 due to the use of more resistant rams on ewes in the Autumn of 2001. By using a ram with an ARR/ARR genotype on ewes that may be of a more susceptible genotype, any offspring produced would be at least in group 2 with 1 ARR allele. The results demonstrate that the proportion of a flock resistant to scrapie can be increased rapidly as a response to the use of scrapie resistant rams.

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The effect of a polymorphism in the MC4R gene within a Meishan synthetic line of pigs

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Introduction The effect of a DNA polymorphism in the MC4R gene on fatness, growth and feed intake traits of pigs was first reported by Kim *et al* in 2000 (1). That study of 1720 animals showed significant effects in several selected breeding populations for days to 110kgs ($p<.001$), 10^{th} rib backfat ($p<.001$), test daily gain ($p<.001$) and feed intake ($p<.01$). However, in the same paper the effect within a small sample (124) from a Meishan synthetic line was not significant and the (small) effect of backfat was in the opposite direction to that reported for other lines. Subsequently, Andersson and colleagues (2) reported a failure to detect an effect in a small QTL population derived from crossing Large White pigs with wild boar. Several explanations have been proposed (1,2) including an epistatic effect. Here we report the results of an experiment to test whether the results from the Meishan population was due to sampling. The results indicated an effect of MC4R within the Meishan line for fatness, growth and feed intake traits in the same direction as previously reported for other lines.

Materials and methods The Meishan synthetic is a line derived by crossing Meishan and Large White populations about 13 years ago. Approximately 30,000 animals from this line were raised under normal management practices under the care of PIC employees at a single nucleus farm in Europe. Animals were put on performance test at approximately 70 days of age and taken off test after 13 weeks. At the end of the test, backfat was measured ultrasonically in real time at the 10^{th} rib 2cm from the centreline. Average daily gain (growth) over the test period was calculated as weight gained divided by days on test. The number of days to 110 kg market weight was estimated by standard procedures, and feed intake was measured with individual electronic measurement equipment.

Genotypes were generated for the population using a combination of DNA testing (1) and genotype prediction using segregation analysis following the method of Kerr & Kinghorn (3). Marker effects were estimated with an animal model using the program PEST (4). Genotypes were fitted as covariables with a value between 0 and 1 of animals being each of the three genotypes. The fixed effects included were farm_season and farm_sex_batch.

Results Table 1 shows the results obtained for the Meishan synthetic population and compares them with the results obtained for the other lines analysed by Kim *et al* (1). The differences between homozygote classes in the Meishan sample were 1.47mm for backfat and 1.61 days for days to 110kgs. Reduced fat depth and the increase in days to slaughter are associated with allele 2 of MC4R. The results appear to be a function of appetite as pigs carrying allele 1 consumed considerably more feed. The effect within this larger sample of the Meishan line are in the same direction and size of effect as that reported for the selected lines (1).

Table 1. The effect of MC4R within the Meishan synthetic line. The average across all other lines reported by Kim *et al* are in parenthesis.

Genotype	Days to 110kgs	Average daily feed intake (kg)	10^{th} rib backfat (mm)
11	0	0	0
12	+0.562 (+1.7)	-0.177 (-0.080)	-0.752 (-0.4)
22	+1.609 (+3.3)	-0.254 (-0.170)	-1.466 (-0.9)

Conclusions With the benefit of additional data from more than 30,000 Meishan synthetic animals the effects of the MC4R gene within the Meishan line can be shown to be consistent within the data reported previously for other lines by Kim *et al*. Allele 2 was associated with reduced feed intake, lower backfat and increased days to 110kgs.

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An *in vitro* analysis of wheat and maize starch degradation

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Introduction The accurate estimation of starch degradation is important for the efficient feed utilisation. The current *in vivo* and *in sacco* methodologies contain a number of drawbacks, including animal welfare issues and high experimental costs including those associated with maintaining surgically modified animal. In addition for many feedstuffs excessive particle loss from *in sacco* bags renders this technique inapplicable. There is, therefore, an opportunity to identify a simple *in vitro* technique to provide the desired data. In pursuit of this goal actual starch degradation was estimated from an analysis of fermentation residues obtained from the *in vitro* degradation of wheat and maize grain. The results were supported with data regarding volatile fatty acid production and fermentation gas release kinetics.

Materials and methods Wheat and maize grain were ground to pass a 2 mm screen. The rumen inoculum was prepared from hand squeezed rumen samples obtained pre-feeding at 07.00h from two lactating cows offered a maize silage based TMR. Fermentation gas production was estimated using the Reading Pressure Technique (Mauricio *et al.*, 1999) with readings taken in three replicates at 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 24, 30, 36, and 48 hours post-inoculation. Total fermentation residues were recovered at 2, 4, 6, 8, 10, 12, 16, 20, 24 and 48 h, bulked and freeze-dried. They were analysed according to Pilgrim (1999) by gelatinisation for 2 h in boiling water-bath and 1.5 h enzymic hydrolysis with the use of amyloglucosidase. Triplicate fermentation residues were recovered at 12, 24 and 48 h for DM degradation. 1.0 ml aliquots of the incubation medium were obtained at 6, 12, 24, 36 and 48 h post-inoculation and analysed for VFA using a GC method. The GLM procedure of SAS was used for statistical evaluation of the experimental data.

Results During the first 6 hours only 0.131g g^{-1} of maize starch had disappeared while the amount of wheat starch was almost double (0.267g g^{-1}). 12 h post inoculation 82.8% of wheat starch was degraded and only 52.2% of maize at the same time. By the end of 48 h almost 100% of both starches were degraded. There was a high regression between starch degradability and cumulative gas production (r^2= 0.9481, p ‹ 0.0001 for maize and r^2= 0.9542, p ‹ 0.0001 for wheat) showing also similar trends for both feeds. The propionate production was higher for wheat during the first hours followed by a much higher production for maize after 24 h and agreed with starch degradation trend.

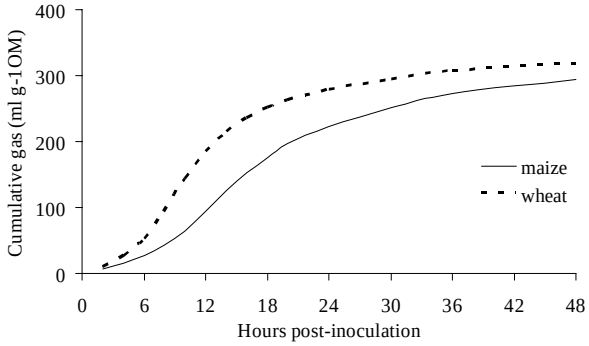

Figure 1: Cumulative gas production

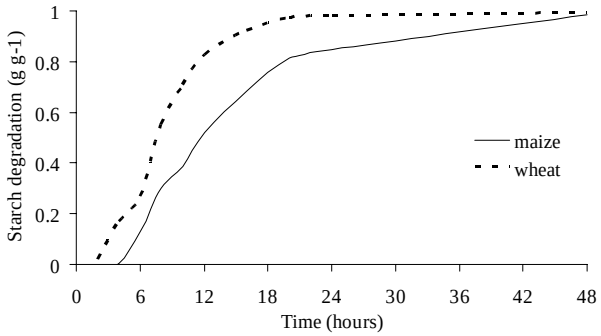

Figure 2: Starch degradation

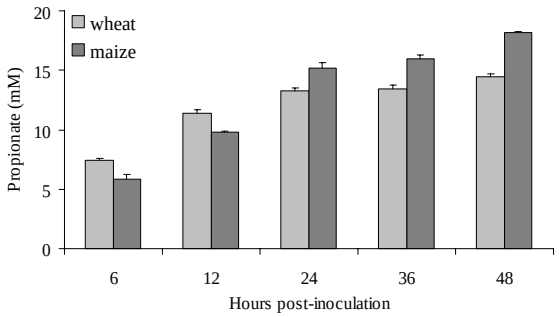

Figure 3: Influence of starch type on propionate production

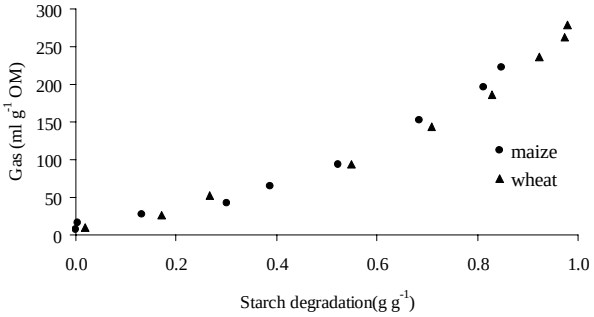

Figure 4: Gas production- starch degradation (0-24 h)

Conclusions Starch degradation was estimated from an analysis of fermentation residues obtained from the *in vitro* degradation. Starch disappearance was able to be measured for the early incubation hours. *In vivo* studies are already being contacted in order to confirm the accuracy of the results obtained during this study.

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Comparison of analytical methods for starch: pure starches and high-starch ruminant feeds

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Introduction In spite of the importance of starch-based feeds for all sectors of the livestock industry, it is difficult to obtain reliable starch estimates. Much of the variation in the accuracy relates to differences in the procedures used. Most starch analyses are enzymatic, relying on the specificity of the enzymes to distinguish the glucose in starch from that in other carbohydrates following gelatinisation. The aims of this study were to compare the accuracy of five different techniques with the aim of selecting the most optimum for future *in vitro* and *in vivo* degradation studies.

Materials and methods Five methodologies – Pilgrim (1999, *M1*), AOAC (1995, *M2*), Hassid & Neufeld (1964, *M3*), MacRae & Armstrong, 1968 (*M4*) and Hall *et al*. (1999, *M5*) were used to measure the starch content of four pure starches (maize, wheat, rice, potato) either alone or in combination with cellulose (1:2 and 2:1). With the exception of Pilgrim (1999), which estimates starch as total carbohydrate less the water-soluble component, the other methods first extract water-soluble carbohydrates in aqueous ethanol. Starch was gelatinised by heating at 90–100 °C for 1 to 4 h, depending on the methodology. In addition Hall *et al*. (1999) used α-amylase and potassium hydroxide. Hydrolysis was achieved by the use of amyloglucosidase and the resulting glucose detected using spectroscopy following treatment with neocupraine (M1), glucose oxidase-peroxidase (M2, M4 and M5) or anthrone (M3). Standard curves were obtained manually (M2-M5) while M1 used an automated calibration. The analyses were replicated four times. Due to poor recovery the Anthrone method (Hassid & Neufeld, 1964) was discontinued. The other methods were then applied in triplicate to five feeds (wheat, maize, barley, wheat bran, maize silage) ground to pass a 1mm screen.

Results Pilgrim (1999) and AOAC (1995) gave recoveries slightly lower than the expected while MacRae & Armstrong (1968) and Hall *et al*. (1999) were both higher. The Hassid & Neufeld (1964) results were extremely low. The presence of cellulose affected the results of all the methods apart from Pilgrim (1999), which together with the AOAC (1995) described more accurately and consistently the starch content of the ruminant feeds examined.

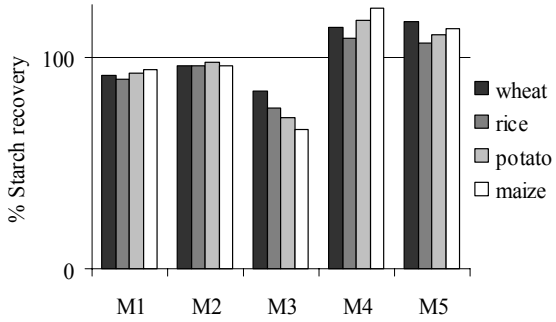

Figure 1: Starch analysis - pure starch

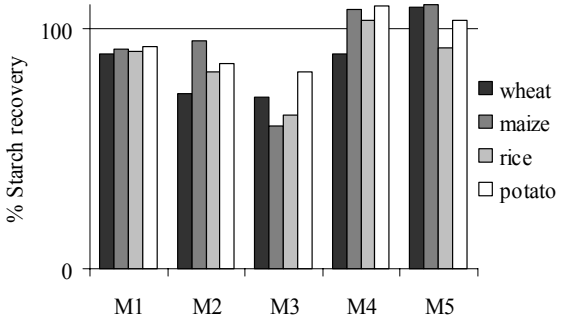

Figure 2: Starch analysis - starch: cellulose (2:1)

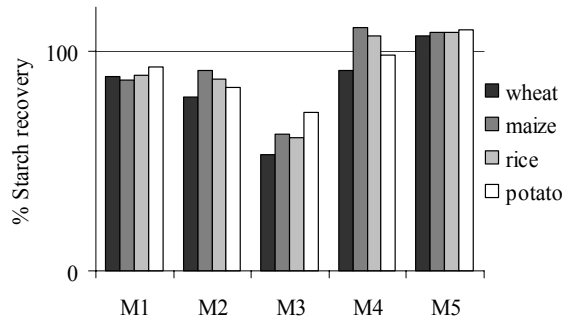

Figure 3: Starch analysis - starch: cellulose (1:2)

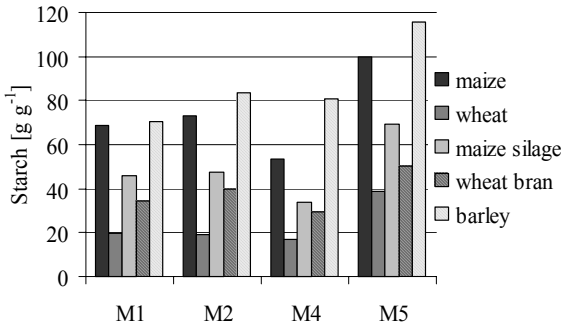

Figure 4: Starch content – ruminant feeds

Conclusions Considering other aspects such as cost and labour the method of Pilgrim (1999) was identified as being the most appropriate for the analysis of starch in animal feedstuffs.

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The effect of Depol 740L and rolling on wheat grain degradability *in vitro*

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Introduction Cereal grains provide the major source of energy for ruminants in intensive production systems. Starch digestion in the rumen appears to be determined by the rate at which both the endosperm cell walls and, more importantly, the protein matrix surrounding the granule can be disrupted by enzymes than the properties of the starch itself. The presence of phenolic compounds influence seed coat digestibility and could interact with the protein matrix to affect starch digestibility. While processing and mastication are sufficient to disrupt these barriers, the rapid fermentation of starch in the rumen is not considered desirable as it can adversely affect animal health (e.g. acidosis) or via a lowered rumen pH inhibit fibre digestion. Processing methods are also criticised in terms of cost relative to inexpensive grain, and environmental issues e.g. alkali loss. A largely unexplored strategy to improve grain digestibility is pre-feeding treatment with exogenous enzymes. In this respect the potential of enzyme preparations, that cleave side-chain linked phenolics, to improve grain digestibility was examined in this study.

Materials and methods Whole wheat grain was used, with the enzyme preparation Depol 740L (Biocatalysts Ltd., Table 3), a *Humicola sp*. product, being applied at 0, 0.1, 0.2 and 0.4. $\mu l\ g^{-1}\ DM$ to either rolled (2 mm) or whole grain. Pretreatment (16h) effect was compared to direct application (0h) of enzymes. In both cases, grains were soaked for 3h in distilled water (0.5 ml g^{-1} grain). Controls (non-soaked grains) were also included. Apart from the direct effect of rolling as a treatment, it was used as a means to mimic mastication as normally when whole grain is incubated, little of any degradation is recorded. The RPT *in vitro* gas methodology of Mauricio *et al.* (1999) was followed to determine gas production and digestibility over a 96 h incubation period. All treatments were examined in triplicate and the results were analysed using the one-way ANOVA statistical test (SPSS 11.0), with significance declared at $P<0.05$.

Results As a direct mechanical effect, rolling achieved a greater degree of disruption and increased both cumulative gas release and organic matter degradation (Table 2), throughout the incubation period. Pretreated grains were degraded to a greater extent throughout the incubation, apart from the 12h period. Soaking promoting disruption and an increase in surface area, accumulated more gas between 2h-12h and 36h-96h. The latter treatment increased OM degradation 12h post-inoculation and onwards, however, at 6h, non-soaked grains were more degradable. The preparation applied at level 2 increased OMD throughout the study and cause a further rise in gas production between 30 and 96h. (Table 1).

Table 1. Cumulative gas production (ml) of pretreated (16h) grains

	2h	4h	6h	12h	24h	30h	48h	96h
Control	1.5ab	2.8a	4.5a	7.5a	15.4a	20.4b	34.7bc	73.7bc
Level 1	0.5c	1.6b	2.9b	5.3b	10.8b	15.7c	29.46c	69.9c
Level 2	1.3b	2.7a	4.5a	8.5a	18.0a	24.4a	41.7a	88.8a
Level 3	1.7a	3.0a	4.6a	7.5a	15.5a	20.4b	35.2b	79.0b
s.e	0.15	0.24	0.32	0.54	1.30	1.77	2.75	3.62

$^{\gamma}$ means in columns with different letters are significantly different (P<0.05)

Table 3. Main enzyme activities in Depol 740L (pH 6.5, temp. 37°C)

Activity	Units
Endoglucanase	612.9
Cellobiase	15.561
Xylanase	12084.5
Xylobiase	1.48
Arabinofuranosidase	2.313
Ferulic Acid Esterase	0.878

μmol reducing component $ml^{-1}\ min^{-1}$

Table 2. The effect of rolling on cumulative gas production (ml) and organic matter degradation (g g^{-1}) on grains

	Cumulative gas					OMD				
	6h	12h	24h	48h	96h	6h	12h	24h	48h	96h
Non-rolled	2.0b	3.6b	6.5b	14.6b	41.5b	0.002b	0.016b	0.030b	0.056b	0.141b
Rolled	4.5a	7.5a	15.4a	34.7a	73.7a	0.009a	0.022a	0.063a	0.117a	0.225a
s.e	0.19	0.43	0.98	2.02	3.24	0.0031	0.0059	0.0054	0.0102	0.0097

$^{\gamma}$ means in columns with different letters significantly differ (P<0.05)

Conclusions Digestibility of grain in all treatments remained low (up to 0.4 g g^{-1}), with neither degradation nor fermentation reaching asymptote levels, indicating an incomplete digestion. However, treatment effects could be observed. Even though rolling impacted on both degradation and fermentation itself, a further increase was caused by the exogenous enzymes. Since disrupting grain structure appeared relatively difficult, rolling enzyme treated grains appeared a prerequisite for an efficient representation of the *in vivo* conditions. Pretreatment was capable of further improving this response. Further research could support the use of enzymes in grain treatment, to overcome important safety and cost issues.

Acknowledgements
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Mauricio, R.M., F.L. Mould, M.S. Dhanoa, E. Owen, K.S. Channa and M.K. Theodorou. 1999. A semi-automated *in vitro* gas production technique for ruminant feedstuff evaluation. *Animal Feed Science and Technology* **79**: 321-330

An *in vitro* model to evaluate nitrogen utilization by rumen microorganisms

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Introduction Many reports indicate that mixed microbial populations preferentially incorporate peptides or NH_4^+ rather than free amino acids [e.g. Pittman and Bryant, 1964]. As part of a study to evaluate a novel encapsulation process, an *in vitro* technique to examine amino acid degradation was developed using a compliment test based on the Reading Pressure Technique [Mauricio *et al*., 1999]. In this methodology, the ability of rumen microorganisms to ferment a pure carbohydrate substrate in a nitrogen-deficient medium was significantly correlated to the level of available nitrogen. It therefore followed that fermentation gas release could be used as a simple technique to examine and quantify nitrogen availability. The study described compared three nitrogen sources offered either alone or in combination.

Materials and methods Individual fermentations were carried out in sealed 125ml serum flasks, containing 1.0 g maize starch [Sigma Aldrich Ltd.] as the energy source. Urea, acid-hydrolysed casein and lysine were used to supply supplemental N in addition to that present in the rumen inoculum [ca. 10 mg flask^{-1}]. The nitrogen sources were examined at differing concentrations to provide a dose titration of 4, 8, 12, 16 and 20 mg additional N flask^{-1} and urea or lysine at 4, 8 and 12 mg N flask^{-1} in combination with casein [4 mg N flask^{-1}]. Flasks containing starch alone acted as controls. A nitrogen-free incubation medium was prepared, based on that of Mauricio *et al*. [1999], but excluding ammonium hydrogen carbonate and reducing solution, with 90ml added per flask. The rumen fluid inoculum was obtained pre-feeding [07.00h] from two dry cows offered a hay / grass silage based total mixed ration and prepared by squeezing through two layers of muslin. Each treatment was carried out in triplicate, with headspace gas pressure measurements were taken at two-hour intervals over an 18 h period. The data were analysed using SAS procedures to obtain LS means and significances of difference.

Results A significant [P<0.001] positive correlation was identified between N addition and cumulative gas volume [Figure 1] for urea and casein [r^2 = 0.944 and 0.951, respectively]. Gas production from lysine remained unaltered [mean value 113 ml] and similar to the control value [106 ml] at 18 h post-inoculation. Supplementing casein with increasing levels of urea [Figure 2] significantly increased the quantity of fermentation gas released [P<0.05] however no significant effect due to the inclusion of lysine was observed.

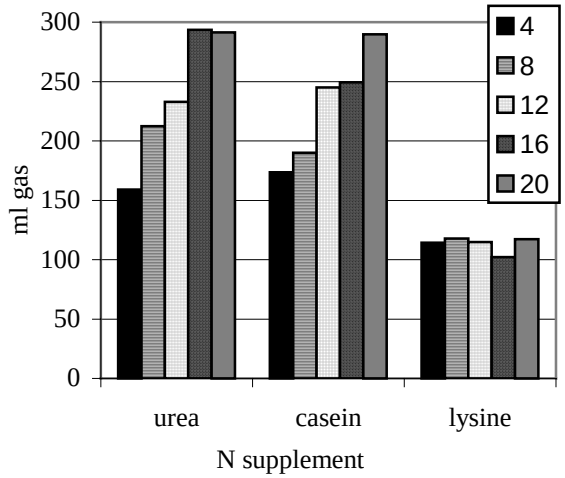

Figure 1. Cumulative gas release [18 h] as influenced by supplemental N source

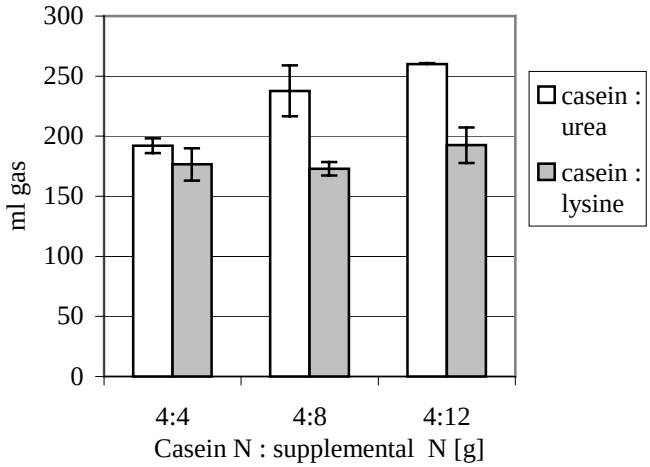

Figure 2. Cumulative gas release [18 h] of casein supplemented with urea or lysine

These results confirm earlier research, which identified that mixed rumen microorganisms are able to metabolise ammonia or acid-hydrolysed proteins such as casein [Pittman & Bryant, 1964]. The study also demonstrated that lysine, when offered as a free amino acid, was poorly utilised. Again this is in line with recent studies, which have been unable to identify either individual or specific combinations of amino acids that significantly influenced rumen fermentation [e.g. Watanabe *et al*., 1993].

Conclusions Not only does this complement *in vitro* technique allow N utilisation by rumen microflora to be examined under controlled conditions but it also offers the possibility of evaluating the degree to which protection techniques render amino acids inert with respect to rumen degradation.

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The use of a nitrogen free medium for *in vitro* fermentation studies

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Introduction The buffered incubation medium used in many *in vitro* ruminant feedstuff degradation assays is essentially that described by Goering and Van Soest [1970]. Hungate [1966] suggested that the actual composition of the inorganic salts in the medium was not vital as long as it provided sufficient buffering capacity and was of a similar osmotic potential to rumen fluid, while Tilley and Terry [1963] argued that sufficient trace elements and "growth stimulants" would be provided by the rumen fluid inoculum or substrate and that fermentation gas would maintain anaerobic conditions. The divergent composition of these media reflects that the microbiologists were attempting to create a "habitat-simulating" media [Hungate, 1966] while nutritionists were using a slightly modified rumen environment *in vitro* to permit microbial degradation of feedstuffs. The objectives of this study were to identify whether reduction of media is necessary prior to use, and to develop a nitrogen free media which could be used for determining the effects of nitrogen supplementation on the fermentation of feedstuffs.

Materials and methods Four incubation media were prepared based on Goering and Van Soest [1970, M1]. For a non-reduced N-containing medium, urea was included in place of cysteine HCl [M2]. Omitting cysteine HCl and replacing NH_4HCO_3 with $NaHCO_3$ produced an N-free, reduced medium [M3]. A non-reduced, N-free medium [M4] was produced by omitting reducing solution from M3. All media were gassed with carbon dioxide [2.0 l min^{-1}] for 30 minutes. These solutions [90 ml $flask^{-1}$] were dispensed into 125 ml fermentation flasks to which 1.0 g substrate [maize starch, grass hay, maize silage, wheat straw or wheat grain, all milled to pass a 2 mm screen] had been added. Five replicate flasks were used for each combination of substrate and media. Flasks were sealed and stored overnight [16 h at 20°C], then raised to 39°C prior to inoculation. Rumen fluid obtained pre-feeding from four late lactation cows [1.0 l cow^{-1}] offered either a grass hay or grass silage based total mixed ration, was strained through a double layer of muslin and 10 ml added to each flask. Headspace gas pressure measurements were taken up to 48 h post inoculation following the methodology of Mauricio *et al.* [1999]. Significances of difference between cumulative gas release as affected by the addition of nitrogen were assessed within feeds using SAS ANOVA procedures.

Results The lack of significant effects between gas release profiles [Figure 1] from maize starch [M1 v M2 and M3 v M4; reduced v non-reduced respectively] indicates that reduction of the incubation media prior to use is not required. It was also shown that N supplementation of the incubation media [+16.5 mg $flask^{-1}$] had no overall effects on cumulative gas release at 48 h for grass hay, maize silage and wheat straw [Table 1], although stimulatory effects were noted for maize silage and wheat straw at 12 h and 24 h and wheat grain at 12 h only. In contrast, N supplementation gave slight negative effects on gas release at 12 h and 48 h for grass hay and wheat grain respectively.

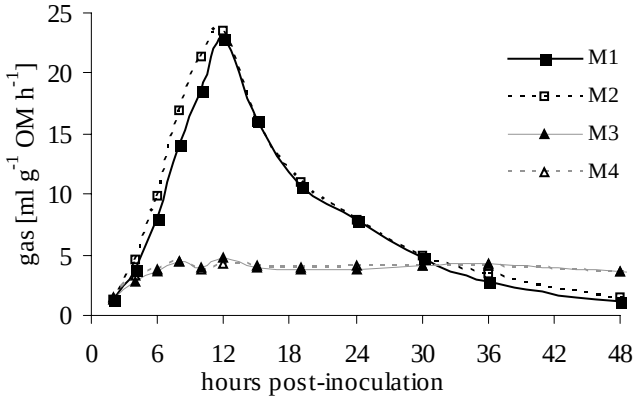

Figure 1. Gas release kinetics – maize starch

Table 1 Cumulative gas release [ml] as influenced by incubation medium nitrogen supplementation

Feed	N	Hours post-inoculation		
		12	24	48
Grass hay	0	47.4^{a}	114.3^{a}	190.7^{a}
	+	43.4^{b}	113.3^{a}	182.7^{a}
Maize silage	0	88.3^{b}	163.5^{b}	237.8^{a}
	+	115.7^{a}	188.2^{a}	241.8^{a}
Wheat straw	0	24.0^{b}	79.7^{b}	152.2^{a}
	+	26.6^{a}	88.9^{a}	154.9^{a}
Wheat grain	0	140.3^{b}	244.8^{a}	308.9^{a}
	+	150.8^{a}	251.9^{a}	298.1^{b}
Pooled S.E.M		2.93	5.30	5.92

Means in columns within feeds with different superscripts are significantly different [P<0.05]

Conclusions From these data it would appear that less rigorous constraints with respect to medium composition and preparation may be applicable for *in vitro* degradation studies. The feeds to be examined and the rumen inoculum are likely to contain sufficient growth factors, with the possible exception of nitrogen in some cases. It is therefore concluded that the *in vitro* media can be radically simplified [by the omission of reducing solution] so reducing cost and improving safety, without losing any analytical precision.

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Protein degradation kinetics of un- and xylose treated soya bean meal by using SDS-PAGE

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Introduction High producing or rapidly growing ruminants require more high quality protein than is provided by rumen microorganisms. This protein can be supplied by increasing the amount of dietary protein escaping degradation in the rumen. Solvent-extracted soya bean meal (SBM), which is a commonly used protein supplement to high producing dairy cows, is palatable with a well-balanced amino acid composition. However, SBM proteins are extensively degraded in the rumen. Attempts to decrease the rate and extent of ruminal degradation of soya bean meal proteins involved treatment with physical and chemical agents. Recently Tuncer and Sacakli (2003) reported that xylose reduce soya bean meal crude protein (CP) degradation in the rumen. To our knowledge, little information is available concerning the type of proteins of un- and xylose treated soya bean meal that leaves the rumen undegraded. The main objectives of our research were to evaluate the degradation of un- and xylose treated soya bean meal proteins by using SDS-PAGE and determine Effective Rumen Degradation (ERD) and intestinal digestibility of un- and xylose treated soya bean meal CP.

Materials and methods Three 600-kg ruminally fistulated Holstein steers were used for *in situ* incubations. Ruminal disappearance of DM and CP from the un- and xylose treated SBM (20g xylose/Kg DM) was measured at 0, 2, 4, 6, 8, 12, 24 and 48 h. The exponential model of Ørskov and McDonald (1979) was used to estimate crude protein degradation kinetic. Digestibility was measured by in vitro method of Calsamiglia et al. (1995). The various degradability parameters for the nylon bags were analyzed by a variance analysis GLM procedure of SAS according to this model: $Y= \mu + Ti + Eij$, where μ is overall average, Ti is the feed effect and Eij is the residual error.
12 mg of well-ground dried un- and xylose treated SBM were placed into 750 µl SDS-PAGE sample buffer. After 30 min of thorough mixing, samples were immersed at 90˚C for 3 min, and then centrifuged at 10000 g for 1 min. A 30 µl of each protein sample was then loaded into the sample well. Samples were fractionated by a SDS-PAGE discontinuous system as described by Laemmli (1970). Electrophoresis of proteins was performed on 12% resolving gels with a 5.0% acrylamide stacking gel. Protein fixation and staining were performed simultaneously using a solution of Coomassie brilliant blue. The subfractions of the gel were then monitored by densitometric scanning at 580 nm.

Results and discussion From the SDS-PAGE pattern and densitometric scanning, conglycinin α and ά sub-units of un- and xylose treated SBM were degraded completely within 4h and 12h respectively, whereas the β sub-unit of β-conglycinin as well as the basic and acidic polypeptide components of glycinin of un- and treated SBM were more resistant to degradation. About 38 and 62 percent of the un- and xylose treated soya bean proteins incubated in the rumen were not degraded after 12 h respectively. The basic sub-unit of glycinin in un- and treated SBM was not completely degraded after 24-h incubation. SDS-PAGE indicated that the basic sub-unit of glycinin and several peptides when untreated SBM, in addition, acidic sub-unit of glycinin and β sub-unit of β-conglycinin when xylose treated SBM is fed to ruminants, make an appreciable contribution to metabolizable protein. Rumen protein degradation characteristics of un- and xylose treated SBM were significantly different ($p<0.05$) (Table 1). The digestibility of the undegradable protein of untreated SBM were higher than xylose treated SBM.

Table 1 Protein degradation parameters of un- and treated SBM

Item	a	b	c	CP ERD(%)at outflow rate 3%/h	5%/h	8%/h
Untreated	15.72[a]	82.01[b]	6.92[a]	72.9[a]	63.3[a]	53.7[a]
Treated	3.03[b]	95.01[a]	3.87[b]	56.5[b]	44.5[b]	[b]34.0

Means in the same column with the same subscription is differ ($p<0.05$).

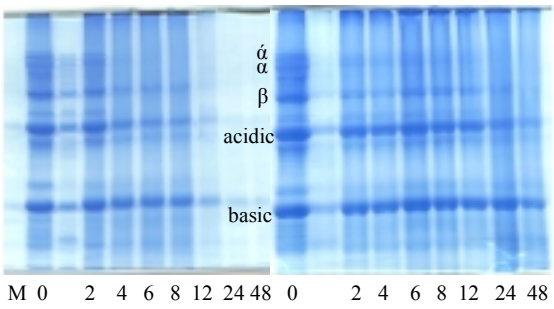

Figure 1 Slab gels of un-(left) and xylose treated SBM(right)

Conclusion Present study demonstrated that SBM proteins can be effectively protected from degradation in the rumen by xylose treatment. Further research is required to examine the effect of xylose treatment on the availability of lysine and other essential amino acids.

Acknowledgment The authors gratefully thank Islamic Azad University for financial support and they would also especially like to thank Mrs saeedeh mousavy for technical support.

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The effect of phenolic acid content on meadow hay digestibility

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Introduction It is widely accepted that diets containing large amounts of forage affect animal performance due to low digestibility of structural carbohydrates. This limitation is mainly attributed to lignification and to covalently bound hydroxycinnamic acids. Most of the work related to the effect of hydroxycinnamic acids on cell wall digestibility has been conducted towards specific plant species and distinct plant parts. However, the results regarding the influence of hydroxycinnamic acids on the digestibility of roughages such as hays and straws are rather scarce. The objective of the present study was to investigate several methodologies in order to evaluate the influence of phenolic compounds on the digestibility of northern Portugal meadow hays.

Materials and methods Six meadow hays from the northern region of Portugal, where the extensive production of the Barrosã native cattle breed predominates, were used in the study. The hays were chosen taking into account its geographical distribution in the region. Gas production profiles were fitted to a two-pool logistic equation (Schofield *et al*., 1994) where V_{FA} = the gas volume of the 1st phase (ml.g OM^{-1}), μ_{mA} = maximum gas production rate of the 1st phase (ml.g $OM^{-1}.h^{-1}$), V_{FB} = the gas volume of the 2nd phase (ml.g OM^{-1}), μ_{mB} = maximum gas production rate of the 2nd phase (ml.g $OM^{-1}.h^{-1}$), λ = lag time; μ_{mA} / V_{FA} = specific rate of 1st phase (h^{-1}); μ_{mB} / V_{FB} = specific rate of 2nd phase (h^{-1}). The *in vitro* DM (D_{GV}), neutral detergent fiber (NDF; D_{NDF}), Cellulose (D_{Cel}) and Hemicellulose (D_{Hem}) digestibilities as well as the in vitro OM digestibility were calculated. The *in situ* DM (a, b, c, a+b, De) and NDF (a, b, c, a+b, De) degradations were also performed. The total esterified and etherified fractions of ferulic (Fer_{tot}; Fer_{est}; Fer_{ete}) and *p*-coumaric (Cum_{tot}; Cum_{est}; Cum_{ete}) acids were determined in NDF residues. The results were subjected to analysis of variance using one-way ANOVA through the GLM procedure of SYSTAT. Principal component analysis (PCA) of data was performed for digestion and phenolic contents variables using SYSTAT.

Results The correlation coefficients between cell wall components showed significant negative correlations between the concentration of phenolic acids and the acid detergent lignin (ADL) and cellulose contents. On the contrary, with the exception of esterified *p*-coumaric acid, the correlations with hemicellulose content were significant and positive. The relationship between the digestibility parameters and the phenolic contents, evaluated by a principal component analysis (Figure 1), showed that Factors 1 (measure of possible distinction between the digestibility end-point measurements and the kinetics parameters) and 2 (measure of the possible distinction between *in situ* kinetics of NDF and the other methods) explained 0.41 and 0.27 of the total variance, respectively.

The parameters related to the digestibility end-point measurements such as the total DM degradability (a+b), total gas production of phases 1 and two (V_{FA} and V_{FB}), the Tilley and Terry procedure (D_{TT}) as well as the digestibility calculated using the method of Goering and Van Soest (D_{GV}) are located in the positive part of the axis. This analysis also denotes the negative relationship between the phenolic contents and the kinetic parameters, and the positive relationship between these phenolic acids and NDF digestibility (D_{NDF}).

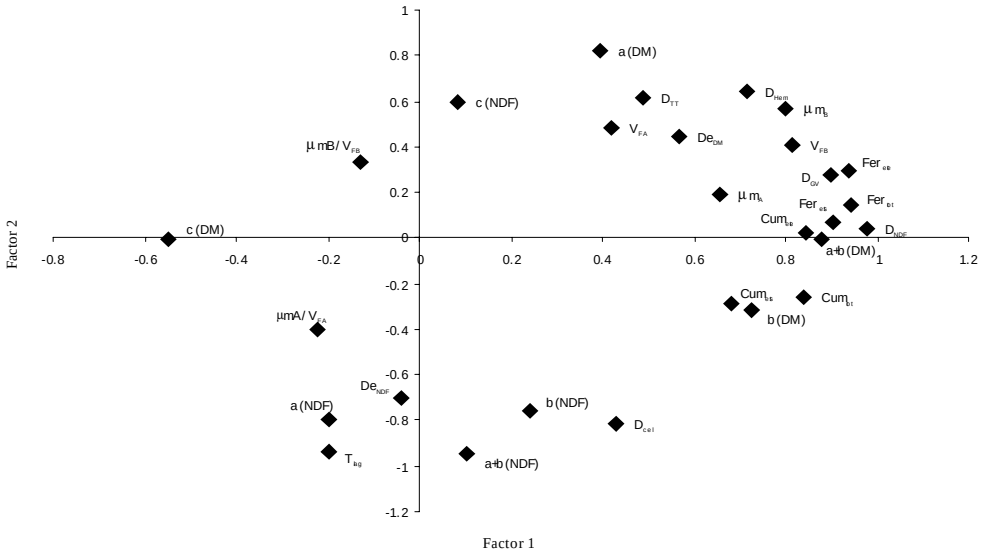

Figure 1 Principal component analysis of the different studied parameters

Conclusions The results of the present study demonstrate that phenolic acids may affect negatively the digestibility kinetics of meadow hays. However there is no influence on the digestibility end-point measurements, indicating that other structural factors are responsible for the low digestibility values normally obtained for these meadow hays. Furthermore, the projection of meadow hays in the PCA axis indicates that they are also very heterogeneous, making the estimation of their nutritive value more difficult.

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Chemical composition and *in situ* protein degradability of maize silage treated with urea and sulphuric acid

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Introduction Maize silage (MS) is a major diet component in Iranian dairy farms. Forage produced from tropical maize hybrids is noted for its high lignin and low water soluble sugar concentrations. This is possibly related to the lower grain and higher non-grain portion of tropical hybrid plants compared to the other hybrids varieties. In addition as tropical maize silage has low nitrogen concentration, it has been suggested to treat the silage by non-protein nitrogen (NPN) in order to alleviate nutritional deficiency in the rumen and enhance roughage utilization. This study was conducted to evaluate the chemical composition and *in situ* protein degradability of maize silage treated with urea (U) and sulphuric acid (SA).

Materials and methods Whole maize hybrid was chopped and ensiled with urea (1.6 or 2.4 % of DM) and sulphuric acid (0.0 or 0.6% of DM) as a 2x2 factorial design. Treatments [MS + 1.6% U ($MS+U_1$), MS + 1.6% U+ 0.6% SA, ($MS+U_1$, SA), MS + 2.4% U ($MS+U_2$), MS + 2.4% U+ 0.6% SA ($MS+U_2$,SA), were preformed in small laboratory silos for 35 day. Silage DM was determined using Air-forced oven (60°C, 48 h) and the chemical composition (CP, NPN, NH_3-N, NDF) were determined using standard procedures (AOAC, 1984). pH was determined in silage extract. DM and protein degradability of the silages were measured by *in situ* technique using two fistulated Holstein steers (400±12 kg). The animals fed a 40:60 concentrate: forage diet. The experimental samples were milled (2 mm screen) and weighed (5 g DM) into bags (12x19 cm) made of polyester cloth with 52µm pore size (8 bags per each sample). The bags were incubated in the rumen for 2, 4, 6, 8, 16, 24 and 48 h after being soaked in distilled water (38° C) for 10 min. Four bags also were washed with cold tap water to estimate the wash-out at zero time. After each incubation time, the removal bags were hand-washed with cold tap water, then dried in a forced-air oven (60° C, 48 h). The degradable coefficients of DM and CP were determined using the equation of $P=a + b (1 - e^{-ct})$.

Result Chemical composition of maize silage treated with U and SA is shown in Table 1. Ruminal degradation coefficients (a, b, c) of dry matter (DM) and protein for MS treated with U and SA are summarized in Table 2. Sulphuric acid caused to reduce the pH, NH_3-N and NPN and increase CP and DM ($P<0.05$). Ruminal DM and CP degradable coefficients influenced by the acid.

Table 1 Chemical composition of maize silage treated with urea and sulphuric acid

Chemical composition	treatment				SEM	*Statistical significant*
	$MS+U_1$	$MS+U_1$,SA	$MS+U_2$	$MS+U_2$,SA		
DM(g/kg)	200^a	234^b	200^a	210^c	1.7	*
PH	3.9^a	3.5^b	4.0^a	3.9^a	0.05	*
CP(g/kg)	90^a	111^b	126^b	144^c	0.2	*
NPN(g/kg)	10^a	9^a	13^b	13^b	0.7	*
NH_3-N (mg/kg)	6.0^a	5.2^a	7^b	6^a	0.4	*
NDF(g/kg)	520^a	560^b	490^c	540^d	2	*

*: $P< 0.05$

Table 2 I*n situ* DM and protein (mean ± SE) rumen degradation coefficients (a, b, c) of tropical maize silage treated with urea and sulphuric acid

Treatments	DM			CP		
	a	b	c	a	b	c
$MS+U_1$	0.27±0.016	0.33±0.034	0.05±0.014	0.67±0.014	0.24±0.159	0.02± 0.022
$MS+U_1$, SA	0.32±0.021	0.21±0.026	0.11±0.038	0.77±0.009	0.17±0.111	0.02± 0.021

a: rapidly degradable fraction, *b:* slowly degradable fraction, *c:* fractional degradation rate constant (h^{-1})

Conclusion Result of the present study indicated that sulphuric acid caused to decrease the DM loss of maize silage. In addition, using of urea in maize silage increase of CP and restricted DM loss. Low NH_3-N and NPN concentrations in silage treated with SA maybe due to low proteolysis in silages. Rapidly degradable fraction of DM and CP of silage. Treated with SA was higher than non-acid tread silage. While slowly degradable fraction of DM and CP in MS treated with acid was notably lower than the other silage. This maybe related to the increase of soluble N and organic matter in the silage treats with acid.

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In situ dry matter and crude protein degradability of halophytes located in central Iran

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Introduction The development of mankind has reached the point that a variety of new resources need to be tapped in order to fill our basic needs for food, feed and freshwater. Halophytes such as *Kochia scoparia, Atriplex dimorphostegia, Suaeda arcuata and Gamanthus gamocarpus* are widely grown in salty lands of central Iran. Halophyte is a plant that naturally grows where it is affected by salinity in the root area or by salt spray, such as in saline semi-deserts, mangrove swamps, marshes and sloughs, and seashores. These plants are grazed by sheep, goats and camels, specially during the prolonged seasons of drought. The dynamic interactions within the rumen are difficult to simulate. *In situ* techniques allow us to study digestion within the rumen itself and reduce the need for ruminal simulation. Such techniques have been used extensively during the last two decades (Vanzant et al, 1998). The aim of this study was to determine the *in situ* dry matter and crude protein degradability of some halophytes located of central Iran.

Materials and methods Samples of halophytes were collected from different regions of central Iran in the summer 2002.The samples of each plant were composited and sub-samples were taken from each composite and dried in an oven at 96º C for 48 h. Dried sample were ground to pass through a 2-mm screen and weighed (5 g DM) into the bags (12 ∗ 19 cm) made of polyester cloth with 50 µm pore size (4 bags for each sample). The bags were incubated in the rumen of two fistulated steers (450 ± 11 kg) for 0.0, 2, 4, 8, 16, 24, 48, 72 and 96 hours. After removal from the rumen, the bags were washed using cold water then were dried in a forced air oven (58º C for 24 h)(Danesh Mesgaran, 2002). The kjeldhal technique used for N analysis. The equation of $p = a + b(1 - e^{-ct})$ was used for determination of degradability parameters. Analysis of variance procedure (SAS institute Inc., 1998) was used to determine the differences between halophytes.

Results *In situ* dry matter and protein degradation coeffecient (a, b, c) for the halophytes are shown in the table 1.

Table 1 *In situ* dry matter and crude protein degradation coeffecient (Mean ± SE) of halophytes

Species	n	DM				CP			
		a	b	c	R2	a	b	c	R2
Kochia sc.	8	0.31±0.02	0.37±0.02	0.09±0.01	0.91	0.35±0.03	0.49±0.03	0.08±0.02	0.87
Atriplex di.	8	0.39±0.01	0.27±0.01	0.09±0.01	0.94	0.50±0.03	0.23±0.03	0.09±0.03	0.67
Suaeda ar.	8	0.53±0.01	0.18±0.02	0.04±0.01	0.75	0.55±0.02	0.17±0.02	0.05±0.02	0.67
Gamanthus ga.	8	0.56±0.01	0.31±0.02	0.07±0.01	0.94	0.66±0.01	0.21±0.02	0.07±0.01	0.86

a:Rapidly degradable fraction
b: Slowly degradable fraction
c: Fractional degradation rate constant (h^{-1})
n: replication

Conclusion There was species differences ($p<0.05$) between dry matter and crude protein degradation characteristics of halophytes. Quickly degradable coeffecient of dry matter and crude protein for *kochia scoparia* was less than other species. Therefore it seems that kochia has higher nutritional potential as fodder for ruminants. In the other hand, quickly degradable coeffecient of dry matter and crude protein of *Gamanthus gamocarpus* was higher than the others. Dry matter and crude protein of *Suaeda arcuata* had the most degradable rate. In general, characteristics of *Atriplex dimorphostegia* and *Suaeda arcuata* (a, b, c) were intermediate in the halophytes examined in the present study.

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Ruminal and post-ruminal digestion of amino acids of some grains measured by mobile nylon-bag technique

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Introduction Modern protein evaluation systems for ruminants describe the supply and requirement of true protein that can be absorbed from the small intestine. Amino acids that are available for absorption from the small intestine is primarily the sum of those of microbial protein that is synthesized in the rumen by microorganism and dietary by-pass protein (Harstad and prestlØkken, 2001). The objective of this experiment was to determine the DM, CP and AA disappearance from barley grain (BG) and corn grain (CG) in the rumen, small intestine and total tract of steer.

Materials and methods The ruminal, post ruminal and total tract disappearance of dry matter, protein and amino acids of samples were determined using the mobile nylon bag procedure (Danesh Mesgaran, 2002). The experimental feeds were barley and corn grains. The plant feeds originated from the Iranian varieties. Three Holstein steers (405±13 kg) fitted with rumen fistula and T-shaped cannulae were used in the present study. They fed 5.1 Kg DM of good quality lucerne hay, 1.2 Kg DM maize silage and 2.7 Kg DM concentrate (171 g CP Kg^{-1} DM) per steer per day. The bags (3x6 cm) were made of artificial silk cloth with a pore size of 48 μm. About 1.2 g dry matter of each feed (grounded through 2 mm screen) was placed in each bag (12 bags per each feed), then inserted into plastic mesh cylinders (26 x 8 cm, 0.57 mm pore size) and incubated in the rumen for 12 h. After removal from the rumen the bags were washed using cold water and those used to post ruminal digestibility (6 bags per each sample) were then inserted into the small intestine via the cannulae at the rate of one bag every 30 min and removed from the voided faeces, rinsed in cold running water. Finally, the bags were dried in a forced air oven (58° C, for 24) and then weighed to determine the dry matter disappearance. The kjeldhal technique used for N analysis. The amino acid analysis was performed according to the procedure of Bidlinger et al. (1984). Data were analyzed using General Linear Model (GLM) procedure of SAS (SAS Institute Inc., 1987).

Results Values for disappearance of DM , CP and amino acids after 12 h of rumen incubation, intestinal passage and total tract for each feedstuff are given in Table 1. There were significant differences between levels of disappearance for both DM and CP between feedstuffs after 12 h of rumen incubation and intestinal passage ($p<0.05$). There was significant difference for AA between feedstuffs after 12 h of rumen incubation ($p<0.05$).

Table 1 Ruminal, post-ruminal and total tract DM, CP and amino acid disappearances (g Kg^{-1}) of barely and corn

Feeds	Intact feed -disappearance in the rumen			Rumen undegraded - disappearance in the intestine			Intact feed - disappearance in total tract		
	DM	CP	AA	DM	CP	AA	DM	CP	AA
Barely grain	640	580	340	410	790	820	840	910	850
Maize grain	350	280	540	560	890	730	910	940	880
s.e.m	23.8	8.1	73	50.1	47	87.17	25. 4	26.31	41.7
statistical significance	*	*	*	*	*	ns	*	ns	ns

DM: Dry Matter; CP: Crude Protein; AA: Amino Acids.
*: $p< 0.05$; ns: $p> 0.05$

Conclusions Within a feedstuff, lower ruminal disappearance of DM, CP and AA was compensated by higher intestinal disappearance of DM, CP and AA, resulting in a small variation in total tract disappearance.

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In situ protein degradability of some feedstuffs used on Iranian dairy farms

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Introduction The undegraded intake protein content of feeds is regarded as a major limiting factor for high performance lactating cows (NRC, 2001). The rate and extent of ruminal protein degradation determine the availability of nitrogen to the microorganisms, and of nitrogenous products in the small intestine. The ruminal and post-ruminal disappearance rates of dry matter (DM) and protein (CP) of protein feeds were shown to be higher than those of energy and forage feeds (Danesh Mesgaran, 2003). On the other hand, the nutritive value of crops is affected by the climatic conditions, and its determination is essential for optimum feeding. The objective of the present study was to determine the in situ DM and protein degradability of some Iranian feedstuffs.

Materials and methods Ruminal degradability of CP and DM of several feedstuffs (lucerne hay, barley grain, sugar beet pulp, wheat bran, maize grain, cottonseeds, soybean meal and cottonseed meal) were determined by using two cannulated steers, averaging 420±8 (SD) kg in body weight. Each steer was fed daily (DM basis) with 5.1 kg good quality lucerne hay, 1.2 kg maize silage and 2.7 kg concentrate (171 g CP kg^{-1} DM). The feedstuffs were ground by using a 2-mm screen and samples (5 g DM) were transferred into polyester bags (12 × 19 cm) with 50 µm pore size. Quadruplicate samples of each feedstuff were incubated in the rumen for 2, 4, 8, 16, 24, 48, or 72 h. Four bags were also washed with cold tap water to estimate the zero time wash-out. After each incubation time, the bags were removed and hand-washed with cold tap water for at least 20 min and dried in a forced-air drying oven (60º C, 48 h), for determination of dry matter disappearance. Nitrogen contents were determined by using the Kjeldhal technique. The degradability coefficients of DM and CP were determined by using the equation $p = a + b (1- e^{ct})$.

Results The in situ degradability coefficients of DM and protein are shown in Table 1.

Table 1 In situ degradability coefficients of DM and CP (mean ± SE) of several feedstuffs used on Iranian dairy farms

Feedstuffs	DM			CP		
	a	b	c	a	b	c
Lucerne hay	0.35 ± 0.03	0.45 ± 0.04	0.06 ± 0.02	0.34 ± 0.02	0.55 ± 0.03	0.06 ± 0.01
Barley grain	0.24 ± 0.04	0.59 ± 0.05	0.06 ± 0.02	0.26 ± 0.06	0.66 ± 0.08	0.05 ± 0.02
Sugar beet pulp	0.35 ± 0.02	0.62 ± 0.02	0.10 ± 0.01	0.37 ± 0.03	0.63 ± 0.04	0.06 ± 0.02
Wheat bran	0.35 ± 0.02	0.45 ± 0.03	0.07 ± 0.01	0.31 ± 0.03	0.61 ± 0.04	0.16 ± 0.02
Maize grain	0.19 ± 0.03	0.79 ± 0.09	0.03 ± 0.01	0.14 ± 0.04	0.55 ± 0.25	0.02 ± 0.02
Cotton seed	0.29 ± 0.05	0.27 ± 0.10	0.04 ± 0.04	0.32 ± 0.08	0.44 ± 0.10	0.07 ± 0.04
Cottonseed meal	0.19 ± 0.03	0.80 ± 0.20	0.02 ± 0.01	0.15 ± 0.05	0.64 ± 0.13	0.03 ± 0.02
Soybean meal	0.27 ± 0.04	0.72 ± 0.06	0.06 ± 0.02	0.17 ± 0.05	0.85 ± 0.09	0.04 ± 0.01

a: rapidly degradable coefficient; b: slowly degradable coefficient; c: fractional degradation rate constant (h^{-1})

Conclusions The results indicated that in situ CP degradability coefficients of the Iranian feedstuffs were different from the published values for similar feeds in the standard feed tables. The a and b coefficients of barley grain CP were notably higher than those of the maize grain. This may due to the protein configuration of maize grain. The characteristics of ruminal protein disappearance rate for sugar beet pulp and wheat bran were similar. The ruminal protein disappearance rate for soybean meal was higher than for cottonseed meal and may be attributed to chemical nature of protein in these feedstuffs. The coefficients can be used to optimize the utilization of protein and energy for microbial yield.

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Chemical composition and *in situ* protein degradability of lucerne silage treated with HCl

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Introduction Lucerne hay or silage is major forage fed to dairy cows in Iran. During fermentation, a large proportion of the CP in lucerne (L) is broken down to NPN; typically, 50 to 60 % to more than 80 %. Therefore, broken down of true protein in lucerne silage (LS) to NPN substantially reduce efficiency of CP utilization in lactating cows (Broderick et al., 1995). The objective of the present experiment was to compare the nutrient content, and in situ DM and protein degradability of LS treated with urea and HCl.

Materials and methods Lucerne was chopped and mixed with different levels of HCl (0.0, 0.4, and 1.2% of DM) and urea (0.0 and 0.5% of DM) and ensiled in laboratory silos for 45 days. HCl was carried and used under the safety protocol of Ferdowsi University of Mashad, using special instruments. The acid (37%) was diluted with water (acid:water 1:4, vol/vol) and stored in an artificial plastic container until it was mixed with the forage. Chemical composition (CP, NPN, N-NH3, and NDF) were determined using standard methods (AOAC, 1980). pH was measured directly in silage extract. The treatments were LS, LS treated with urea (0.5% of DM) and HCl (0.4% of DM), (LSu_1+a_1), and LS treated with urea (0.5 % of DM) and HCl (1.2 % of DM), (LSu_1+a_2). Rumen degradability of CP and DM were determined using in situ technique in two fistulated steers (body weight of 420 ± 8 kg). The experimental samples were ground (2mm) and weighed (5 g DM) into bags (12 × 19 cm) made of polyester cloth with 50 µm pore size (4 bags per each samples). Bags were incubated in the rumen for 2, 4, 8, 16, 24, and 48 h. Four bags were also washed with cold tap water to estimate the zero time wash-out. After each incubation time, the removal bags were hand-washed with cold tap water for at least 20 min and dried in a forced-air oven (60°c, 48 h). The degradable coefficients of DM and CP were determined using the model of $p=a+b\ (1-e^{ct})$. Data were analyzed using GLM procedures of SAS.

Results Chemical composition of LS and LS treated with urea and HCl is shown in Table 1. HCl and urea caused to reduce pH, NH3-N, and NDF and increased CP and NPN ($P<0.05$). Ruminal degradation coefficients of CP and DM are summarized in Table 2. The coefficients of a and b were higher in the silages treated with HCl and urea than control silage, but the coefficient of b in control silage was higher than the other silages.

Table 1 Chemical composition (%) of lucerne silage treated with urea and HCl

	Treatments				
Item	LS	LSu_1+a_1	LSu_1+a_2	SEM	*P-value*
pH	5.6^a	4.6^b	4.4^b	0.66	0.01
CP (g	16.8^a	19.8^a	21.2^b	2.23	0.01
NPN	6.6^a	12.8^b	12.1^b	3.42	0.01
NDF	53.0^a	38.5^b	39.5^b	8.09	0.01
NH3-N*	-	20.8^a	11.0^b	6.92	0.01

* NH_3-N in 100 ml of silage extract

Table 2 In situ DM and CP degradable coefficients (Mean ± se) of lucerne silage treated with urea and HCl

	DM			CP		
Treatments	a	b	c	a	b	c
LS	0.32±0.17	0.36±0.29	0.05±0.01	0.54±0.01	0.25±0.04	0.05±0.02
LSu_1+a_1	0.36±0.21	0.28±0.03	0.07±0.02	0.64±0.01	0.12±0.02	0.07±0.04
LSu_1+a_2	0.42±0.01	0.38±0.03	0.05±0.01	0.67±0.01	0.23±0.03	0.04±0.01

a: rapidly degradable coefficient; b: slowly degradable coefficient; c: fractional degradation rate constant (h^{-1})

Conclusion The results of the present study demonstrated that HCl improved the nutritional value of the LS. HCl may reduce proteolysis during ensiling by either reduction of pH or by providing additional substrate to enhance the reduction of pH. In addition acid treatment of LS caused to decrease the soluble N and predicted ruminal degradation of CP in the forage.

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Effects of additives on fermentation quality and *in vitro* digestibility of millet silage

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Introduction In arid and semiarid areas, the possibility of growing high yielding forages such as corn is limited. Therefore interests have been focused on growing plants which are highly able to express their potential in hot and dry conditions. Millet has recently received considerable attention as a suitable candidate. Some advantages include: rapid growth rate, relatively high resistance to drought and salinity, moderate protein content, palatability and absence of prussic acid. The objective of this experiment was to evaluate the fermentation quality and digestibility of millet silage as affected by various additives.

Materials and methods Whole plant millet (Panicum *milliaceum*) was harvested at milk and soft dough stages of maturity (DM: 25.32 and 29.54 g/100g, water soluble carbohydrates (WSC): 4.05 and 5.54 g/100g respectively), left untreated (C) or treated with ground barley (B, 5 g/100g wet basis), molasses (M, 5 g/100g wet basis), formic acid (F, 0.3 g/100g wet basis), lactic acid producing bacterial inoculant (I, Ecosyl, providing 10^5 CFU/g based on manufacture instruction), and combination of molasses plus inoculant (M+I). All silages were prepared in 3 replicates in 450gr plastic containers, manually packed, sealed and then put in plastic bags. After 45 d ensiling period, silos were opened and DM, pH, ammonia nitrogen (NH_3-N), residual WSC, organic acids and *in vitro* organic matter digestibility (IVOMD) were determined (Tilley and Terry, 1963). Data were analyzed in a completely randomized design by a 2*6 factorial arrangement and 3 replicates. Proc. GLM of SAS (SAS Institute, 1989) was used and means were compared using Duncan's multiple range tests where *f* test was significant.

Results Stage of maturity had no significant effect on NH_3-N, residual WSC, lactic acid and IVOMD, but values for DM and pH were significantly different. Higher pH, elevated NH_3-N, and relatively higher butyric acid content indicated clostridial fermentation in control silages. Addition of M and M+I resulted in lower pH, higher production of lactic acid and lower butyric acid. Across treatments, the lowest NH_3-N was observed in formic acid treated silages. Bacterial inoculant lowered the ammonia content of silage to marginal level (~ 10 g/100g total N), but did not increase lactic acid production. Comparing to control group, use of additives increased IVOMD of silages. Within additive treated silages, those contained M and M+I had numerically higher IVOMD (Table 1).

Table 1 Fermentation parameters and IVOMD of millet silage as affected by stage of maturity and additives

	Stage of maturity			Additives						
	Milk	Soft dough	SE	C	B	F	I	M	M+I	SE
DM	24.71^{a}	26.98^{b}	0.15	23.76^{d}	26.24^{b}	24.99^{c}	24.29^{cd}	27.69^{a}	28.06^{a}	0.26
pH	4.42^{a}	4.21^{b}	0.01	5.42^{a}	4.48^{b}	4.00^{d}	4.36^{c}	3.91^{d}	3.71^{e}	0.03
Residual WSC	0.82	0.74	0.09	0.15^{c}	$<0.1^{c}$	1.04^{b}	0.13^{c}	1.69^{a}	1.63^{a}	0.03
NH3-N g/100g TN	9.46	10.45	0.48	23.9^{a}	9.58^{b}	4.54^{c}	9.91^{b}	6.02^{c}	6.32^{c}	0.83
Lactic acid	1.38	1.33	0.07	0.95^{c}	1.17^{c}	1.07^{c}	1.17^{c}	2.18^{a}	1.57^{b}	0.13
Acetic acid	0.59^{a}	0.43^{b}	0.03	1.33^{a}	0.46^{c}	0.2^{d}	0.76^{b}	0.29^{cd}	ND	0.05
Butyric acid	0.12	0.08	0.007	0.20^{a}	0.03^{cd}	0.09^{b}	0.15^{a}	0.07^{bc}	ND	0.01
IVOMD	60.79	60.70	0.07	56.09^{c}	60.53^{ab}	60.98^{ab}	59.39^{bc}	63.00^{ab}	64.54^{a}	1.2

ND=Not detected, values for organic acids and IVOMD are expressed on g/100g DM basis
In each row, means with different letters significantly differ (P<0.05)
Interaction effect of stage of maturity and additives was only significant for organic acids

Conclusions Results of this study clearly showed the need for adding a source of water soluble carbohydrate to millet in order to obtain good quality silage. Also inoculation of lactic acid bacteria does not necessarily promote homolactic fermentation if insufficient amounts of water soluble carbohydrates are presented.

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Effect of drying treatments used for legume forages on the concentration of condensed tannins

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Introduction Some herbaceous legumes have shown a dry tolerance and had been used as animal feed. However, some of those plants have anti nutritional compounds such as tannins that can interfere on intake and digestibility. Tannins are polyphenolic compounds originated in a secondary metabolism of the plant as protection against insects, birds and as a result of drought, temperature or soil fertility. In order to preserve the tannin for experimental purposes, it is suggested that the hay preparation should be made under shadow. The objective of this work was to compare the concentration of phenolics compounds in forage legumes havested in dry and wet seasons and under sun, shadow and air circulation dry.

Material and methods The collection of the material was made in the semi-arid area of Pernambuco, located in the Brazilian Northeast. The climatic conditions of this region are extremely harsh with temperature between 25 and 34ºC and average annual rainfall oscillating between 600 to 900 mm. Three browse species with potential as forage were selected randomly in approximately 280 ha: Aroeira (*Astronian urundeuva*, Engl.), Jurema preta (*Mimosa hostilis*, Benth), and Malva branca (*Sida cordifolia*, L.). The samples were collected at 2m height or inferior and with 5mm or less of diameter. The collections were made in the dry (March) and the wet season (October) with four replicates each substrate. Three drying treatments were tested: control, dried in air drying oven at 40^{o} C (Control) during 2 days, sun-driying (Sun) and shade-drying (Shade) during 3 days. The extraction of the phenolic compounds was made with a solution of acetone (70%) as described by Makkar (2000). Starting from this extract, the content of total phenolics (TP) was determined using Folin-Ciocalteu reagents, total tannins (TT) as the difference of phenolics before and after tannin removal using the insoluble polyvinylpolypyrrolidone (PVPP) as described by Makkar (2000) and condensed tannins (CT) were analyzed by the Butanol-HCl method in a proportion 95:5 v/v (Poter et al., 1986). Data were compared by least square means using SAS system (SAS, 2000).

Results All three parameters (TP, TT and CT) were significantly different among either plant or season ($P<0.05$), however, the influence of the treatments were observed only on CT (Table 1), except for Malva branca. Plants harvested in the dry season showed higher TP, TT and CT than in the wet season. These results confirm the hypothesis that the drought stimulates phenolics compounds production. No significant effects were observed among treatments ($P>0.05$) on the wet season. CT measured at dry season showed significantly higher values when artificial drying was applied ($P<0.01$). Shade drying did not show significant differences to sun drying even in the dry season ($P>0.05$) contradicting our expectation. This could have happened because not only sunrays cause the tannin to bind but also temperature may influence it. The results found for TP, TT and CT are shown on Table 1.

Table 1 Means of condensed tannins* (CT, in g.kg^{-1} DM) for three legumes forage in dry and wet season applying three drying treatments: control, sun and shade.

	Dry season				*Wet season*			
	control	*sun*	*shade*	*season*plant*	*control*	*sun*	*shade*	*season*plant*
Aroeira	84.15^{a}	51.72^{b}	57.80^{b}	64.56^{B}	30.92^{c}	34.70^{c}	36.10^{c}	33.91^{B}
Jurema preta	114.97^{a}	97.95^{b}	105.47^{ab}	106.13^{A}	54.52^{c}	62.17^{c}	62.52^{c}	59.74^{A}
Malva branca	0.37^{a}	0.57^{a}	0.45^{a}	0.47^{C}	0.17^{a}	0.50^{a}	0.17^{a}	0.28^{C}
*Season*treat*	66.50^{a}	50.08^{b}	54.57^{b}	-	28.54^{c}	32.46^{c}	32.93^{c}	-

$^{a, b, c}$ values with different superscripts, within rows, are significantly different ($P<0.05$)
$^{A, B, C}$ values with different superscripts, within columns, are significantly different ($P<0.05$)
* standard errors: for substrate (SE = 1.447); for treatments (SE = 1.477); for season (SE = 1.206); for season*plant (SE = 2.089); for season*treatment (SE = 2.089)

Conclusion In the wet season all those three drying treatments presented no difference and the choice can be made based on economic factors. In the dry season, in order to have the CT preserved the oven drying (control) was the best choice. It is suggested for next studies to control the environmental temperature.

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Chemical composition, and in vitro and in situ protein digestibility of some halophytes located in central Iran

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Introduction During the last two decades, there has been increased interest in planting halophytes in the salty agricultural regions of central Iran for improved animal production and environmental protection. The aim of this study was to determine the chemical composition and protein digestibility of some halophytes (*Atriplex sp., Sauda sp., Kochia sp. and Gamanthus sp.*) using in vitro technique, and mobile nylon bag and three step procedures.

Materials and methods Samples of the halophytes were ground (2-mm screen), then analysed for total N (Kjeldhal method), NDF, fat, ash, Na, Cl, K, Cu, Fe and Mg. For the protein digestibility study (8 replicates for each plant), the in vitro procedure [McNiven et al. 2002; samples were weighed into small nylon Ankom bags, sealed, and incubated in borate-phosphate buffer for 1 h, 39º C using Daisy Incubator (Ankom Technology, USA). Then, protease solution was added and the bags were incubated for 4 h. Bags were incubated for I h more into pepsin solution followed by 24 h incubation in pancreatin solution. Finally, bags were rinsed, dried and the N content was determined] and the mobile nylon bag technique (Danesh Mesgaran, 2002) was followed. The 3-step procedure was also used (Calsamiglia and Stern, 1995). Approximately 1.5 g of sample was weighed into a Dacron polyester bag and suspended in the rumen of a cow for 12 h. Samples of ruminal undegraded were weighed into a 50 ml tube. Then, 10 ml of HCl-pepsin solution was added and incubated for 1 h in a shaking water bath at 38.6° C. After that, 0.5 ml of 1 N NaOH and 13.5 ml of phosphate-pancreatin buffer were added and the tubes were incubated for 24 h at 38.6° C. After the incubation, 3 ml of TCA was added to each tube and centrifuged (10,000 x *g*, 15 minutes). Part of supernatant (5 ml) was analysed for N concentration. Analysis of variance procedure (SAS Institute Inc., 1998) was used to determine the effects of species on protein digestibility.

Results Table 1 shows the chemical composition of the halophytes. Species effects on protein digestibility estimated by different laboratory methods are presented in Table 2.

Table 1 Nutrient and mineral content (% of DM) of the halophytes

Species	CP	NDF	Fat	Ash	Cl	Na	K	Fe	Mg	Cu
Atriplex sp.	6.2	61	0.9	16.9	2.6	4.1	1.50	0.03	0.13	0.04
Suaeda sp.	7.5	47	2.4	32.5	2.9	6.8	1.43	0.01	0.17	0.08
Kochia sp.	11.7	57	1.2	11.6	2.4	1.8	0.90	0.03	0.14	0.03
Gamanthus sp.	6.7	48	1.3	41.4	2.8	12.1	0.80	0.03	0.11	0.06
SEM	1.2	4.2	0.6	3.4	0.3	1.30	0.3	0.009	0.04	0.01

Table 2 Protein digestibility (%) of some halophytes estimated by in vitro, in situ and three step procedures

Method	Species				SEM	Statistical significant
	Atriplex sp.	*Suaeda sp.*	*Kochia sp.*	*Gamanthus sp.*		
In vitro	60.5[a]	62.1[a]	62.7[a]	80.4[b]	8.3	*
Mobile nylon bags	49.0[a]	57.8[a]	73.4[b]	54.0[a]	.2	*
Three-step	75.5[a]	72.1[a]	76.5[a]	82.9[a]	7.2	ns

*: P< 0.05; ns: P> 0.05

Conclusions Species influenced (P< 0.05) protein digestibility measured by the in vitro and mobile nylon bag techniques. In this study, it was found that, in general, *Kochi sp.* may be better than the other species because this halophyte had a higher nutritive value (especially low ash and high protein levels) and a higher protein digestibility compared with the other halophytes. However, there is a need to investigate the presence of anti-nutritional factors and animal response to this plant.

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The effect of silage microbial inoculant with and without additional preservatives on the aerobic stability of maize silage

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Introduction Yeasts are the first micro-organism that become active in the silage upon exposure to air, using the residual sugars and lactic acid to produce carbon dioxide. Maize silage is particularly prone to spoilage as maize silage tends to have a larger concentration of water soluble carbohydrates, which was considered to be a better substrate for micro-organisms than volatile fatty acids (Auerbach *et al*., 1998). The aim of this experiment was to measure the effect of inoculating maize silage with Maize-all GS (inoculant) and Sil-all Fireguard (inoculant and preservative) on aerobic stability.

Materials and methods 1800kg (FM) of forage maize (v Ivory) sown (25th April 2002), harvested (30th October 2002, DM 29 (±1.29)) and divided into equal sub-samples (300 kg FM). Each sub-sample of forage maize had one of the following experimental treatments applied: No additional additive with 200 ml of water / 100 kg FM (0), Sil-All fireguard 0.5g/100kg FM (SAFS), Maize Maize All GS 1g/100kg FM (MAS). Sil-All fireguard contains inoculant of *lactobacillus plantarum* and *salivarius, Pediococcus acidilactici*, potassium sorbate, sodium benzoate and three sugar releasing enzymes. Maize All GS contains inoculant of *lactobacillus plantarum* and *salivarius, Pediococcus acidilactici* and three sugar releasing enzymes. A total of 18 experimental silos (3 replicates of each treatment) were double lined with polythene and filled directly following the application of the treatment additives, placed into the silo in approximately 75 mm layers, consolidated using approximately 80 kg of pressure, until the forage silo was completely filled. The silos were immediately compressed using 120 kg of pressure to remove air was and immediately sealed. The silos were then fitted with a loose filling top which had a weight of approximately 75 kg/m^2 applied, stored at a constant ambient temperature between 17 and 20°C for 30 days. On opening samples of the silage were obtained from each replicate treatment and analysed for chemical composition. All containers were punctured with 20, 0.5-cm diameter holes to allow air movement, insulated using 5cm polystyrene foam, stored at a constant ambient temperature (17 to 20°C). Aerobic stability was defined as the time taken for the temperature of the silage to increase more than 2 °C above ambient temperature. The data was found to be normally distributed and analysed by parametric analysis using the ANOVA general linear model (Minitab 13.32). The existence of significant treatment effects were assessed using Tukeys test.

Results

	0	SAFS	MAS	s.e.m.	Sig.
Lactic acid levels (g/kg) Change between 0 and 48 h	-16	5.6	-11.7	6.60	NS
Lactic acid levels (g/kg) Change between 48 and 168 h	-37.2 ^{b}	-78 ^{a}	-52.5 $^{a b}$	11.90	**
Lactic acid levels (g/kg) Change between 0 and 168 h	-53.2 ^{b}	-72.4 ^{a}	-64.2 ^{a}	5.56	**
Acetic acid levels (g/kg DM) Change between 0 and 48 h	-8.2 ^{c}	0.6 ^{a}	-2.2 ^{b}	2.60	**
Acetic acid levels (g/kg DM) Change between 48 and 168 h	-6.4	-24.4	-16.2	5.20	NS
Acetic acid levels (g/kg DM) Change between 0 and 168 h	-14.6 ^{b}	-23.8 ^{a}	-18.4 ^{b}	2.67	**
Maximum pH	7.3 ^{a}	6.7 ^{b}	7.4 ^{a}	0.22	**
pH change over 0-48 hours	0.3	-0.1	0	0.12	NS
pH change over 48-168 hours	3.3 ^{b}	3.0 ^{c}	3.6 ^{a}	0.17	**
Maximum temperature (º C)	24.1	25.2	23.0	0.64	NS
Time to reach max. temp. (h)	83.1 $^{a b}$	109.1 ^{a}	74.5 ^{b}	10.40	**
Time taken to increase temp. by 2 º C (h)	41.1 ^{b}	76.5 ^{a}	56.4 $^{a b}$	10.30	**

Lactic acid levels showed the greatest levels of increase with MAS and SAFS applied. Acetic acid levels showed the lowest initial levels of change in MAS and SAFS, but showed no significant difference at 48 to 168 hrs of aerobic exposure.

Discussion: The acetic acid levels, maximum pH and pH change were significantly lower in SAFS. The time taken to reach maximum temperature and the increase by 2 º C (h) was significantly reduced and thus aerobic stability was increased significantly by the application of MAS. Lactic acid level changes were significantly greater in MAS and SAFS.

Conclusion: Application of silage additives MAS and SAFS increased both lactic acid levels. Aerobic stability of silage was greater with the application of MAS and SAFS as indicated by an increased amount of time to reach maximum temperature and reduction in maximum and silage pH change.

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The effectiveness of biological treatment of wheat straw with 8 strains of white rot fungi

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Introduction In the developed world, wheat straw is commonly regarded as a waste product. An obvious application is as an animal feed source, however, the digestible sugars (cellulose and hemicelluloses) are chemically bound within lignified cell walls. This severely inhibits its digestibility and thus its energy and nutritive value by ruminants. Various methods have been used to increase its digestibility and nutritive value by breaking, or weakening the linkages between the lignin and hemicelluloses prior to it being fed to ruminants. Where grass and silage are abundant and relatively cheap sources of animal feed, it is not cost effective to try and utilize this resource. However where alternative feed sources are not readily available, low cost upgrading of an abundant source of fodder would have many benefits. The objectives of this study were to use 8 strains of white rot fungi to pretreat wheat straw to improve its *in-vitro* digestibility, and to determine the impact of the fungi on the *in-vitro* digestibility method, i.e. to see if fungi have any adverse effects on the digestibility method.

Materials and methods Wheat straw (*Triticum aestivum*) was collected from the University research farm, Abergwyngregyn, and sub-sampled according to MAFF (1986) standard technique. The 8 strains of white rot fungi used where: *Pleurotus ostreatus* (027) and (136); *Pleurotus eryngii* (DSM8264); *Phanerochaete chrysosporium* (S179) and (S596); *Trametes versicolor* (CTB863A) and (PRL28A) and *Heterobasidion annosum* (GOT121). The fungi were cultured on 2% malt agar plates and introduced into twenty eight 100g bags of roughly chopped wheat straw. After inoculation the bags were incubated for 4 weeks at 27°C, and 70% relative humidity. A moisture content of around 70% was maintained within the bags. After four weeks, all samples where dried at 105°C for 24 hrs and milled to pass a 1 mm screen. Crude protein was determined by the Kjeldahl procedure (MAFF, 1986) using a Kjeltec 1030 auto analyser. The in-vitro dry matter digestibility (IVDMD) was determined using the faeces liquor method (Omed *et al*., 2000). Lignin was determined according to the Effland (1977) method. To determine the effect of fungi on the faecal liquor method, fungi, grown on 2% malt broth for 4 weeks as above, were blended in the growth medium and 20 ml was added to blank faecal liquor assays. The data were analysed by one-way analysis of variance using the ANOVA function of MINITAB (version 13).

Results No improvement in the *in-vitro* digestibility of the wheat straw was achieved by treatment with the white rot fungi used although a significant reduction in lignin content was observed with *P. chrysosporium* (S179)*, T. versicolor* (28A), and *P. ostreatus* (027) (Table 1.1). The fact that lignin depletion was not reflected in the crude protein and *in-vitro* digestibility of the wheat straw, suggests that the fungi used in this experiment, displayed simultaneous attack characteristics (i.e. depleted lignin, cellulose and hemicellulose at similar rates), rather than the selective lignin degradation, which was desired in this context. The results showed no negative effect if the fungi grown alone (without straw) on the faecal liquor technique. Therefore it can be said that the *in-vitro* digestibility analysis technique used to analyse the digestibility of the wheat straw in this experiment was providing valid results.

Table 1.1 Mean percentage figures of crude protein, lignin, and IVDMD of fungi treated wheat straw

Source	*S179*	*S596*	*CTB863 A*	*28A*	*DSM826 4*	*136*	*027*	*GOT121*	*Control*
Mean % CP	3.50	3.50	3.29	3.29	3.00	2.95	2.78	2.60	2.59
Mean % Lignin	15.47	18.60	16.06	13.13	18.14	18.97	13.08	17.51	18.87
Mean % IVDMD	23.44	23.17	28.06	22.11	26.08	26.56	21.71	22.62	27.17
Mean % IVDMD[1]	61.04	57.88	56.06	54.39	58.84	60.60	57.66	55.75	57.14

Mean % IVDMD[1] = impact of fungi on in-vitro digestibility method, where grass of known IVDMD was used as control.

There were no significant differences (P≥0.05) between strains for any of the variables.

Conclusions Whilst the fungal treatments yielded no significant increases in nutritive value or *in-vitro* digestibility of the wheat straw (at P=0.05), the lignin degradation exhibited by *P. chrysosporium* (S179)*, T. versicolor* (28A), and *P. ostreatus* (027), albeit from simultaneous attack, suggests that these species and strains thereof, do have a great deal of potential for being adapted for use in this context. The results also showed that fungal metabolites did not inhibit the digestive capability of the rumen microflora. This implies that the fungi did not have negative effects on the estimation of IVDMD by the faecal liquor technique, nor the digestibility value of the forage when consumed by ruminant animals.

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Prediction of short chain fatty acids in rumen fluid using near infrared reflectance spectroscopy (NIRS)

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Introduction Short chain fatty acids, produced from the fermentation of feedstuffs, form the ruminant's primary energy source, as well as being precursors of glucose, protein and milk constituents (Dijkstra *et al*., 2000). The analysis of rumen fluid to estimate short chain fatty acids involves the addition of internal standards and analysis by gas chromatography. NIRS has been shown to have the potential to accurately and rapidly evaluate fresh silage chemical and biological parameters, including short chain fatty acids (Park *et al*., 1998). This study was undertaken to evaluate the potential of NIRS to accurately estimate the chemical composition of rumen fluid when a range of diets were fed to fistulated steers.

Materials and methods Nine rumen fistulated Aberdeen Angus steers were used in this study. Treatments consisted of 12 basic forages; grass, high digestibility grass silage, low digestibility grass silage, high dry matter grass silage, low dry matter grass silage, maize silage, whole crop wheat, hay, lucerne hay, straw, fodder beet and potato, fed either alone or in combination, giving a total of 24 treatments, calculated to have constant metabolisable energy (ME) intake. The experiment was conducted over eight 16-day periods, allowing three replications per treatment. On days 15-16 rumen liquor samples were taken at -1, 1, 2, 4 and 6 hours after the morning feed (9:30am), and 1, 2, 4, 7, 11, 14 and 16 hours after the evening feed (4:30pm). The pH and ammonia nitrogen were recorded. Short chain fatty acids were determined using gas chromatography. Rumen fluid was frozen for NIRS analysis. Rumen fermentation data were statistically analysed using the Genstat REML procedure for the analysis of unbalanced data to remove animal and period effects. Time means were compared using within animal variation. These statistically analysed data were used for the NIRS calibrations. The rumen fluid was thawed, centrifuged at 3000 g for 10 minutes and equilibrated to 37ºC prior to scanning on a Foss NIRSystems 6500 spectrophotometer using a transflectance static cup. Optical values were recorded as log 1/Reflectance (log 1/R) over the wavelength range 1100 – 2500 nm. An average spectrum for each treatment at each sampling time was calculated giving 288 scans. Modified partial least squares (MPLS) regression technique was used to develop calibrations for the rumen parameters. Cross validation was performed and the optimum mathematical treatment selected (i.e. lowest standard error of cross validation (SECV)). A blind validation was performed by randomly selecting 81 samples for validation and running the optimum regression on the remaining 207 samples.

Results The calibration and validation statistics presented in Table 1 show that the R^2 and cross validation coefficient (R^2cv) are all very high. The standard error of calibration (SEC) and SECV are small (2-9% error of the means) (not shown), except for ammonia nitrogen concentration and valerate (14 & 16% error respectively). This is also reflected in the standard error of prediction (SEP) for the validation set. Valerate which is usually present in very small concentrations in rumen fluid was not as accurately predicted by NIRS.

Table 1 NIRS calibration and validation statistics for chemical parameters of rumen fluid

Parameter	Calibration (n=207)				Validation (n=81)			
	SEC	R^2	SECV	R^2cv	Mean	SEP	R^2cv	% Error
pH	0.09	0.84	0.12	0.75	6.44	0.16	0.69	2.48
Ammonia (mmol/l)	0.76	0.98	1.29	0.95	9.16	1.74	0.95	19.0
Acetate (mmol/l)	2.98	0.84	3.87	0.73	61.3	4.30	0.66	7.02
Propionate (mmol/l)	1.11	0.92	1.41	0.88	19.0	1.96	0.83	10.3
Butyrate (mmol/l)	0.80	0.92	0.95	0.89	10.4	1.64	0.75	15.8
Valerate (mmol/l)	0.39	0.91	0.58	0.79	3.50	0.87	0.70	24.9
Total SCFA (mmol/l)	4.09	0.91	5.09	0.86	94.2	6.46	0.81	6.86
Molar proportion								
Acetate	10.5	0.94	13.1	0.91	656	19.5	0.83	2.97
Propionate	7.79	0.88	10.0	0.79	200	15.8	0.66	7.88
Butyrate	6.72	0.90	8.11	0.85	110	14.4	0.64	13.1
Valerate	4.07	0.85	5.46	0.73	33.9	8.15	0.65	23.9

Conclusion The study shows that NIRS could be a useful tool for the rapid estimation of pH, and total short chain fatty acid concentration (mmol/l). The prediction of individual acid concentrations (mmol/l) and molar proportions of acetate, propionate and butyrate in rumen fluid were quite good.

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Prediction of chemical parameters of whole crop wheat and maize silages by near infrared reflectance spectroscopy (NIRS)

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Introduction Whole crop wheat and maize silages are becoming more widely used as additional winter forage for ruminant animals Whole crop wheat and maize forage can be produced with greater nitrogen efficiency than grass swards (Aarts *et al*., 1992) and it has been shown that forage maize inclusion in grass silage based diets has resulted in increased DM intake, milk yield and milk protein content (Keady *et al*., 2002). Consequently a robust, cost-effective method to accurately characterise the feeding value of these forages is required. Previous research at this Institute (Park *et al.*, 1998) has shown that NIRS can be used successfully to estimate the chemical and biological parameters of grass silage. The objective of this study was to examine the potential of NIRS to predict the chemical composition of whole crop wheat and maize silages.

Materials and methods Approximately 1 kg each of two hundred and fourteen whole crop wheat and maize silages, were obtained from commercial farms across Ireland. The silages had been precision chopped through a forage harvester. An extract of the fresh silage was obtained using 30 g sample in 150 ml distilled water and pH and ammonia nitrogen estimation performed. The remainder of each sample was dried at 60ºC for 48 h and milled through a 0.8 mm screen using a Christy Norris cross beater mill. Chemical analysis was determined for crude protein using the micro kjeldahl method and starch was estimated using the method of Keppler and Decker (1974). A dried milled sample of each silage was scanned in duplicate on a NIRSystems 6500 scanning monochromator using a static ring cup. Spectral data were recorded as log 1/Reflectance (1/R) at 2 nm intervals over the wavelength range 1100-2498 nm. Spectrally, whole crop wheat and maize silages were very similar (Mahalanobis distances < 3) and so were combined to form one calibration. The chemical data were regressed against the optical values using a modified partial least squares (MPLS) regression technique. A range of mathematical transformations and scatter corrections were applied to remove extraneous noise and optimize the chemical information within the spectra. Cross validation was performed to avoid over-fitting. The optimum equations were selected on the basis of the lowest standard error of cross validation (SECV).

Results The mean, minimum, maximum and standard deviation in chemical composition of the silages were 4.08, 3.56, 9.02, 0.617; 58.5, 30.6, 194, 20.1; 90.6, 64.2, 179, 20.0; 8.66, 0.20, 35.0, 4.64; 215, 40.25, 387, 97.6; for pH, ash (g/kg DM), crude protein (g/kg DM), ammonia N (% total N) and starch (g/kg DM) respectively. The calibrations developed for prediction of chemical parameters of whole crop wheat and maize silages silage all produced very high coefficients of determination (R^2) and cross validation (R^2cv). The standard error of calibration (SEC) and (SECV) were very low for pH, crude protein and starch. The error for ash was acceptable, as being the inorganic fraction of the forage it is predicted through association with organic compounds present in the sample. The calculated percentage error of the mean was very acceptable, ranging from 3-8% approximately, except for ammonia nitrogen which represents a 15% error.

Table 1 NIRS calibration statistics for chemical parameters of dried milled whole crop and maize silages

Parameter	Calibration statistics							
	n	Mean	SEC	R^2	SECV	R^2cv	% Error	Factors
pH	418	3.97	0.11	0.82	0.12	0.80	3.0	11
Ash (g/kg DM)	415	55.67	4.29	0.91	4.61	0.90	8.2	9
Crude protein (g/kg DM)	405	86.88	4.69	0.86	4.99	0.84	5.7	11
Ammonia N (% total N)	411	7.90	1.11	0.88	1.20	0.88	15.2	10
Starch (g/kg DM)	231	212.1	9.18	0.99	10.42	0.99	4.9	11

Conclusion This study has shown that NIRS can be used as an accurate method for the rapid chemical analysis of dried samples of whole crop wheat and maize silage.

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Comparison between *in sacco* and *in vitro* methods to estimate rumen degradability of feeds

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Introduction Strained rumen fluid (SRF) obtained from slaughtered animals has been used to estimate *in vitro* dry matter degradation (DMD) of feeds (Mohamed *et al*., 2002). This study compared *in vitro* methods using SRF either from fistulated or slaughtered sheep with *in sacco* method to estimate *in vitro* degradation of various feed raw materials.

Material and methods The *in vitro* method using SRF from fistulated sheep (SRFF) was used simultaneously with the *in sacco* method by employing 3 rumen fistulated sheep (mean liveweight 83±1kg) fed twice daily fixed amounts of a diet containing hay (65%) and concentrate (35%). However, the *in vitro* method using SRF from slaughtered sheep (SRFS), one freshly slaughtered on each of three separate occasions, was used in a separate study. Wheat feed (wht), maize gluten (mz), peas, beans, rapeseed meal (Rsd) and soyabean (Sb) were incubated in polylester bags for the *in sacco* determination and in test tubes for the *in vitro* DMD for different times (0, 6, 18, 24, 48, 72h). *In sacco* bags containing about 4 g of each feed (2mm) were placed in duplicate in the rumen of each sheep before feeding. Bags were removed at specified times, washed with cold running water until the water ran clear. DMD was calculated after the bags had been dried. Degradation at zero time was estimated by submitting bags containing samples to the same washing procedure. For the *in vitro* DMD whole rumen contents obtained either from fistulated sheep or from slaughtered sheep were strained through cheesecloth to obtain SRFF or SRFS respectively. About 0.4g of each feed (<1mm) was incubated in duplicate at 39 ºC with buffered SRFF or buffered SRFS for various times. After each incubation, residues were washed, dried and weighed to estimate DMD. Blanks were also run to correct DMD. Excel was used to study relationship between *in sacco* and both *in vitro* DMD for each feed at each incubation time, whereas, GLM of SPSS was used to examine the effects of methods, feeds and time and significance was declared if $P<0.05$.

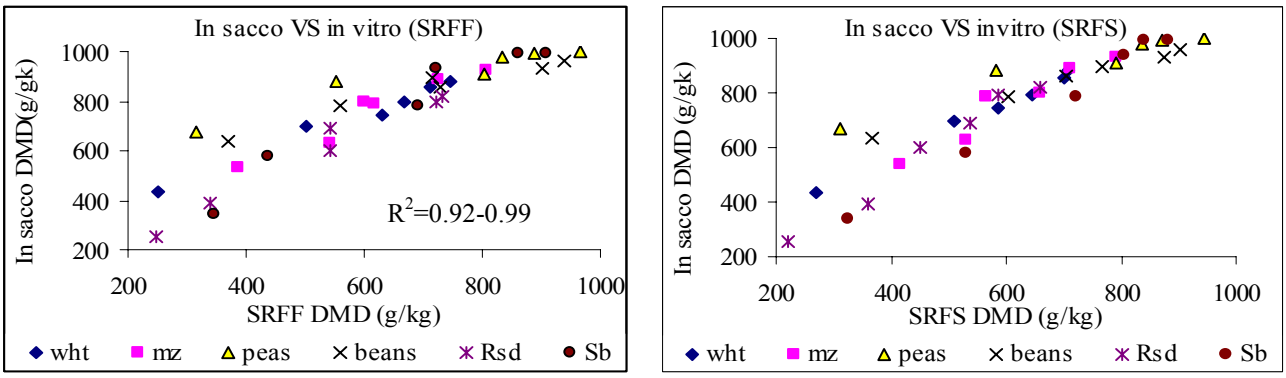
Results The main effects of methods, feed and time were significant ($P<0.01$). *In sacco* DMD (g/kg) and *in vitro* DMD using either SRFF or SRFS inocula for each feed, averaged over sheep and times (*n=36*) are shown in Table 1. *In sacco* produced significantly higher DMD ($P<0.05$, s.e.=3.4) whereas, no significant difference was found between DMD using SRFF and SRFS ($P>0.05$). Individual comparison of feeds showed that *in sacco* gave the highest DMD for each feed. Peas produced the highest DMD compared to other feeds (Table 1). Figure 1 shows strong correlations between *in sacco* DMD and *in vitro* DMD for each feed (*n=2*) at each time, averaged over sheep (*n=3*). Average DMD increased with time ($P<0.05$). The overall mean DMD for feed of this study using SRFS match well with the DMD using SRFF.

Table 1 Mean DMD (g/kg)

Method	Wheat	Maize	Peas	Beans	Rapeseed	Soyabean	Average	Proportion of *IS*
In sacco	735±25	761±24	905±20	845±19	592±36	771±41	768.0^{a}±13	1
SRFF	585±30	613±24	727±39	702±34	520±31	661±35	634.7^{b}±14	0.83
SRFS	570±27	613±23	723±38	704±32	469±27	684±35	627.0^{b}±14	0.82

Values with different superscripts in the same column differ significantly ($P<0.05$). *IS = in sacco*

Figure 1 Correlations between *in sacco* and *in vitro* methods



Conclusion The *in sacco* method produced higher DMD estimates for all feeds. However, the *in vitro* DMD values for both SRFF and SRFS inocula were still lower than those for *in sacco* DMD. The *in vitro* DMD of feeds correlated well with the *in sacco* degradability of the corresponding feeds. The DMD values obtained using SRF from slaughtered sheep were quite comparable to those produced by SRF obtained from fistulated sheep and also ranked feeds in a similar way as the *in sacco* method. This study showed that SRF obtained from freshly slaughtered sheep could be used to replace SRF obtained from fistulated sheep for *in vitro* incubation of feeds to estimate degradation of ruminant feeds.

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Deactivation of tannins in *Leucaena leucocephala*

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Introduction Tannins can produce toxic and anti-nutritional effects in monogastric and ruminant animals: reduced feed intake, lower nutrient digestibility and protein availability. *Leucaena leucocephala* has high concentration of condensed tannins (about 6 % CT), however is probably the most widely in use tree legume in the world. The aim of this experiment was to evaluate different treatments to deactivate tannins in *Leucaena leucocephala*.

Material and methods *Leucaena leucocephala* samples were collected randomly from different parts of the field over a period of 3 consecutive days (sub-samples): branches (stems and leaves, < 0.5 cm diameter) were cut using stainless steel knives. Sub-samples were pooled and after treatments three replicates were taken for analysis. Fresh material was placed in straw bags and transported to the laboratory as soon as possible. Drying method, urea and ash treatments were carried out. Samples were prepared and sun-dried (90 % DM). Other samples of fresh material were treated with urea (4% urea DM basis) and kept in plastic boxes with lids for 20 days. Wood ash treatment was used too, and samples were kept in a 10% wood ash solution (pine wood ash, pH 10-11) for 12 hours. Plants were analysed for dry matter (DM), ash, nitrogen (N), crude protein (CP = N × 6.25), by standard procedures (AOAC, 1995). They were also analysed for acid detergent fibre (ADF) and neutral detergent fibre (NDF) contents (Van Soest et al., 1991). Samples were also analysed for total phenolics, extractable and condensed tannins, according to Makkar (2000).

Results Table 1 provides information on the chemical composition of Leucaena. CP contents for fresh, sun-dried and urea treated Leucaena (23.4, 19.7 and 21.6 %, respectively) are high and similar to values found in literature (Hove et al., 2001). Ash treated Leucaena showed lower CP content compared to the other treatments (17.6 %). Table 2 lists the total phenolics and tannin contents. Sun drying reduced the total phenolics (TP), total (TT) and condensed (CT) tannins content of 76.8, 79.7 and 81.4% in relation to fresh Leucaena. Urea treatment resulted in a decrease of 86.1, 89.9 and 98.4 % of the TP, TT and CT contents. Ash treatment (12h) decreased the TP, TT and CT concentration compared to the fresh treatment in 96.1, 97.1 and 99.3%, respectively (P<0.01). The decrease in tannin content of *Leucaena leucocephala* after sun drying was observed by other authors (Makkar and Singh, 1991). The same authors did not observed an effect of drying of mature oak leaves under different conditions on the levels of TP, CT, protein precipitation capacity and cite this could be due to the lower moisture content.

Table 1 Chemical composition (g.kg^{-1}) of Leucaena leucocephala treated in various ways

constituent†	*Leucaena treatments*			
	fresh	*sun-dried*	*urea 4%*	*ash (24h)*
DM	301.9	874.9	364.2	227.4
OM	927.3	937.4	934.9	951.2
NDF	593.6	541.7	741.1	837.6
ADF	281.1	390.7	425.0	595.2
CP	234.1	197.1	216.7	176.5

† DM: dry matter; OM: organic matter; NDF: neutral-detergent fibre; ADF: acid-detergent fibre; CP crude protein

Table 2 Tannin analysis of Leucaena

Leucaena treatments	*constituent*†		
	total phenolics	*total tannins*	*condensed tannins*
fresh	13.71 [a]	11.72 [a]	6.88 [a]
sun dried	3.18 [b]	2.38 [b]	1.28 [b]
urea 4%	1.90 [b]	1.11 [b]	0.11 [b]
ash			
1 h	1.23 [b]	0.93 [b]	0.25 [b]
12 h	0.75 [b]	0.54 [b]	0.11 [b]
24 h	0.71 [b]	0.50 [b]	0.07 [b]
SE	0.955	0.742	0.478

† total phenolics and total tannins, in g TA equivalent per 100 g DM; condensed tannins, in g catechin equivalent per 100 g DM;
[a, b] means with different superscripts, within column, are significant different (P < 0.01)

Conclusions All treatments reduced TP, TT and CT contents. Ash treated Leucaena showed the lowest values, but they were not different of sun-drying and urea treatments. Further studies should be done to certify that the deactivation of tannins chemically observed will result in a positive response by the animals.

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The effect of Depol 670 L and Depol 740L on wheat straw digestibility

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Introduction Plant cell wall polysaccharides are degraded by microorganisms provided that they produce the necessary enzymes and in sufficient quantities. Some polysaccharides, such as hemicelluloses, are highly complex branched structures, which require a wide range of enzymes for their degradation. A further complication in the hydrolysis of these polysaccharides occurs because some sugar residues are esterified to phenolic compounds, such as *p*-coumaric and ferulic acids. Feruloyl groups reduce accessibility of enzymes to the main chain and may also act as nucleation sites for lignification. Feruloyl esterases and arabinofuranosidases which work in synergy with main enzymes to increase the removal of phenolics, including lignin, should enable xylanolysis and cellulolysis to proceed more effectively. The effect of enzyme preparations rich in debranching enzymes on the degradation of poor quality roughage was examined.

Materials and methods Wheat straw pre-dried at 65 °C and milled through a 2 mm screen was used. Depol 670L, a liquid blend of fungal enzymes was applied at 0, 5, 10, 20 and 40$\mu l\ g^{-1}$ *DM*. Depol 740L, a ferulic acid esterase product from *Humicola sp*., was applied at 0, 0.05, 0.1, 0.2 and 0.4 $\mu l\ g^{-1}$ *DM*. Both enzyme preparations (Table 2) were active in a pH range of 4 - 6 and mainly mesophilic (40 - 65 °C) (Biocatalysts Ltd.). The RPT *in vitro* methodology (Mauricio *et al.,* 1999) was used to determine *in vitro* gas release and digestibility. Controls containing enzyme, without any substrate, were included to account for any gas production due to either stabilisers or carriers. Pretreatment (16h at 20ºC) of straw was compared to direct enzyme application (0h). All incubations were conducted in triplicate and the data was analysed using the one-way ANOVA statistical test (SPSS 11.0), with significance declared at $P<0.05$.

Table 1 Organic matter degradation (OMD) of straw pretreated (16h) with Depol 670L (g g^{-1})

	6h	12h	19h	24h	48h	96h
Control	0.013c	0.074c	0.200a	0.314a	0.461b	0.597a
Level 1	0.034b	0.088bc	0.214a	0.293bc	0.481a	0.584b
Level 2	0.049a	0.100bc	0.193a	0.300ab	0.489a	0.594ab
Level 3	0.036b	0.110ab	0.200a	0.243d	0.478a	0.559c
Level 4	0.046a	0.111ab	0.117a	0.278c	0.478a	0.568c
s.e.	0.0027	0.0151	0.0194	0.0074	0.0058	0.0058

[γ] *means in columns with different letters significantly differ (P<0.05)*

Table 2 Enzyme activities in preparations (pH 6.5, temp. 39 °C)

Activity	Depol 670L	Depol 740L
Endoglucanase	4857.8	612.9
Cellobiase	5.561	15.561
Xylanase	664.81	12084.5
Xylobiase	0.962	1.48
Arabino/dase	1.318	2.313
F.A. Esterase	0.268	0.878

μmol reducing component ml^{-1} min^{-1}

Results As regards cumulative gas release, no or even a negative effect was observed when Depol 670L was directly applied at 0h, while straw pretreated at levels 1-3 released more ($P<0.05$) gas between 72h and 96h compared to the control. Pretreating (16h) straw with Depol 740L also numerically increased gas yield throughout the incubation period but significantly ($P<0.05$) between 72 and 96h at levels 1 and 2 (181, 186 and 195, 201ml compared to the control 170 and 183 ml, respectively). The same levels, in contrast, caused a decrease during the same period when applied at 0h. Further, in terms of degradation, with direct application of enzymes, only level 1 showed an increased degradation at 6h, while for 16h pretreatment with Depol 670L all levels increased OMD ($P<0.05$) for the same period and at 48h of incubation, while levels 3 and 4 caused a rise at 12 h (Table 1). Depol 740L applied at level 1 directly before inoculation increased OMD at 6h compared to the control. During pretreatment, an increased rate was detected at 6h of incubation (levels 1 – 3), i.e. 0.025, 0.020 and 0.016 against the control being degraded at 0.013 g g^{-1}. Improved OMD and cumulative gas production, suggested an increase in both fermentation and degradation, caused by direct hydrolysis or by a possible synergism between the exogenous enzymes and the rumen microorganisms.

Conclusions Pretreating straw played an important role in improving digestion profiles. The observed improvements due to pretreatment may have been achieved by the creation of an enzyme-feed complex that allowed a greater concentration of enzymes to reach the substrate. Alternatively, enzyme preparations could have acted similarly to a primary coloniser, initiating degradation earlier and increasing the surface area available for microbial attack, with the end result being enhanced fibre degradation. Supplemented enzyme activities increased the hydrolytic potential of the rumen fluid. An increased initial OMD can advantageously affect intake and subsequently overall animal performance. However, further research, possibly using even purified feruloyl esterase or arabinofuranosidase, is required in order for the net effect of debranching activities on the digestion of poor quality forages to be examined.

Acknowledgements
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Pre-weaning differences in sucking, feeding, and drinking behaviour of piglets weaned at 3, 4 or 5 weeks of age

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Introduction Weaning demands a nutritional change and although piglets voluntarily consume creep feed in appreciable quantities from about 4-5 weeks of age, they still rely on milk as an important food source for a long time (Boe 1991). The purpose of this study was to investigate the differences in pre-weaning behaviour of piglets weaned at 3, 4 or 5 weeks of age.

Materials and methods The experiment was conducted according to a randomised block design, with two replicates and three treatments. A replicate comprised six litters weaned at 3, 4 or 5 weeks of age respectively. Nine sows were selected that had similar litter-sizes for the purposes of this study. Piglets were weighed at birth and subsequently every seven days. Piglets had their teeth and tails clipped and were given an iron injection on the day of birth. A high quality, commercial creep feed and a drinker were provided and the daily intake of the litter was recorded from day 14 of lactation. All wasted and refused feed was removed from the creep bowl and weighed. The sows were provided with feed according to the Stotfold Feeding Scale, developed by MLC, and were fed twice daily. From day 14, all the piglets in the litter were identified (by means of a unique combination of coloured stripes on their backs. For each weaning age, six piglets were selected from each litter. As the weight of piglets is often inversely related to their experience of feed pre-weaning, and their growth rate in the immediate post-weaning period, the 2 heaviest, the 2 lightest and the 2 piglets closest to the median weight of the litter at weaning were selected. The piglets have been monitored using a time-lapse video recording device, 24 hours a day, from 14 days of age to the respective date of weaning. Once the selection had been made at weaning, the eating, drinking, fighting and sucking behaviour of the chosen piglets (n=54) was analysed through videotapes using *Observer 3.0* software. At the end of the experimental period, piglets weaned at 3, 4 and 5 weeks of age were observed for 168, 336 and 504 hours respectively for each litter. Because of the non-normal distribution of the data the values were square root or $\log_{10}$ transformed, as appropriate, and analyses was carried out using GLM-ANOVA in Minitab 12 for Windows. However, for clarity of the presentation, untransformed values are shown in the table and text.

Results

Table 1 Frequency and duration of behaviours, during the week post-weaning, for piglets weaned at 3, 4 or 5 weeks of age.

Behaviour	Weaning age			SED		
Mean values	3 weeks	4 weeks	5 weeks	3-4	3-5	4-5
Fight Freq (b) (scores/week/piglet)	26.74	19.56	10.94	0.075	0.097***	0.101***
Fight Dur (a) (sec/week/piglet)	2334	1746	1246	0.075	0.097***	0.101***
Drinking Freq (a) (scores/week/piglet)	41.1	48.1	20.8	0.057	0.073***	0.077***
Drinking Dur (b) (sec/week/piglet)	1350	1328	766	2.414	3.099***	3.256*
Eating Freq (b) (scores/week/piglet)	38	27	25	0.064**	0.082**	0.086
Eating Dur (b) (sec/week/piglet)	1602	1123	1763	3.236	4.154	4.366
Suckling Freq (a) (scores/week/piglet)	335	303	258	0.016	0.021***	0.021***
Suckling Dur (sec/week/piglet)	108019	106259	78040	5365	6886***	7237***

**P<0.01, ***P<0.001.
SED refers to the data which have been transformed using square root or $\log_{10}$ transformation in order to be treated with GLM-ANOVA.
(a) = transformed data using $\log_{10}$, (b) = transformed data using square root. Due to the fact that this behavioural work was very extensive (1008 hours of continuous monitoring), a low number of replicates was used that could reduce the repeatability of some measures.

Conclusion Piglets weaned at 3 weeks spent longer involved in aggressive behaviour (14 minutes) than piglets weaned at four (P>0.05) or five weeks of age (P<0.001) (10 and 7 minutes respectively). The larger proportion of the time spent on fighting, is part of the process for the formation of social hierarchy that take place during the 3rd and 4th week of their life (Petersen 1994). As the age at weaning increased, the number of visits to the feeder declined, while the proportion of time spent per visit increased. The results show that piglets which were weaned at an older age (4-5 weeks) became more 'nutritionally wise', as they employed their time more efficiently in finding and utilising other available food sources, rather than stimulating the sow to nurse more frequently (P<0.001) and provide more milk. It also suggests that the sow was unable to provide sufficient nutrients for their growth at that stage. The older pigs were more successful in finding creep feed pre-weaning. Their familiarity with the type of feed and feeder in the pen, should make them better able to cope with the changes in food supply post-weaning and minimise the lag phase.

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The welfare of deer and wild boar at slaughter: the results of a producer survey

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Introduction Meat from exotic farm animals such as farmed deer and wild boar is currently widely available to the consumer within the UK. Despite a rapid growth in production there is a paucity of research that focuses on the welfare of these animals during their slaughter. The objective of this study was to survey deer and wild boar producers to establish information about current slaughter practices. In addition producers' opinion on current practice was ascertained.

Materials and Methods Surveys were designed for each set of producers. Questions were in the main forced answer with opportunity for open-ended responses. The questions were in two sections; factual and attitudinal. Factual questions addressed enterprise type, distances travelled to the abattoir, type of weapon used, and site of slaughter. Attitudinal items included the acceptability of journey length to the abattoir, the acceptability of handling during lairage and any consequential value loss to the carcass. Open-ended questions were posed regarding current slaughter practices, the acceptability of using the same slaughter methods as for comparable domestic species and the preference for on-farm slaughter. Questionnaires were distributed by post to members of producer associations.

Results Responses were received from 60 deer producers (response rate 43%) and 8 wild boar producers (36% response rate). 88% of deer producers farmed red deer and 23% farmed fallow deer, of these 12% farmed both species. In addition 12% owned other deer species. Table 1 summarises the responses. 57% of wild boar farmers also reported that it was inappropriate to slaughter wild boar using methods designed for domestic pigs.

Table 1 Summary of the responses by deer and wild boar farmers to questioning on the slaughter of their animals.

	Deer	Wild boar
Distance travelled to abattoir	35% < 40 miles	75% <40 miles
	53% > 100 miles	25% 60-80 miles
Location of slaughter	48% on-farm	25% on farm
	40% specialist abattoir	75% at abattoir
	12% multi-species abattoir	
Method of slaughter	51% free bullet	29% electrical stunning
	16% captive bolt	57% 270 rifle
	29% unknown	14% 12 bore rifle
Is the journey length to the abattoir	29% unacceptable	14% unacceptable
acceptable?	71% acceptable	86% acceptable
Are animals handled appropriately	48% frequently	67% frequently
during lairage?	42% don't know	33% don't know
Has handling during lairage ever caused	38% never	67% never
loss of value to the carcass?	31% don't know	33% don't know
Is the lairage provision acceptable?	12% unacceptable	33% unacceptable
	73% acceptable	67% acceptable
Are you concerned about how your	76% no	57% no
animals are slaughtered?	19% yes	29% yes
		14% don't know
Would you prefer on-farm slaughter?	62% yes	63% yes
	15% no	37% no

Conclusion
These results illustrate current practice within these industries but tell us little about the suitability of these practices in terms of maximising carcass quality and ensuring good welfare practices. Potential areas for research identified by this project include; the acceptability of distances travelled to the abattoir and the suitability of slaughter methods. In addition, it appears that producers are often unaware of practices used during lairage and slaughter. This may result in producers being unable to make educated decisions about abattoir choice. Wild boar farmers tended to be more concerned about slaughter methods than deer farmers, this difference mainly relates to concerns over the employment of methods used for domestic pigs. These methods may be unsuitable for wild boar due to anatomical, behavioural and management differences and require future investigation. Both deer and wild boar farmers expressed a preference for on-farm slaughter. This may have implications for the development of mobile slaughter schemes.

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Effect of cushioned flooring in cubicle housing and out wintering on all-weather pads on behaviour and foot lesion scores of pregnant dairy heifers

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Introduction Comfort is of particular importance during the peri-partum period when cows are particularly susceptible to claw lesions. Claw lesions are reduced by housing on straw bedding which is thought to be in part attributable to the physical surface (Bergsten and Frank, 1996) but also to the fact that cows in straw yards spend more time lying down (Singh et al., 1993). The objective of this study was to determine the influence of relief areas in cubicle housing and out-wintering on a woodchip pad on behaviour and foot lesion scores of pregnant dairy heifers.

Materials and methods Sixty-six in-calf, spring-calving Holstein-Friesian heifers were blocked on liveweight and expected calving date and assigned to three housing treatments from 25/10/02 to 15/01/03: Concrete = free-access cubicles bedded with rubber mats with concrete slatted flooring in the passageway and solid concrete flooring at the feed face (CON, n=22); Cushioned = as for CON but with cushioned flooring (RJM Anti-Lameness Mat, R.J.M. Mooney, & Son Ltd., Avonbeg Industrial Est., Dublin 12, Ireland) in the slatted passageway and at the feed face (CUS, n=22); Woodchip pad = all-weather wood-chip lying area with concrete feeding area (PAD, n=22). The activity, posture and location of all heifers was monitored by instantaneous scan sampling every 15mins for 24h on four occasions (approx. once/month) and for 12h (0800-2000) every other week during the housing period. Observations started approximately 10 days after heifers entered the housing treatments. Claws of the hind limbs were inspected for lesions, which were scored according to severity every 4 weeks starting the week prior to housing. Behavioural data are presented as the average across observation days; treatment effects were assessed by analysis of variance. Foot lesion scores were analysed using repeated measures ANOVA. All tests were performed using SAS.

Results PAD heifers spent significantly more time standing and less time lying than both CON and CUS heifers throughout the housing period (Table 2). CUS heifers spent longer standing and less time lying than CON heifers and spent longer feeding than either CON or PAD heifers. CUS heifers stood in the passageway more than CON heifers. PAD heifers had significantly lower foot lesion scores than both CON and CUS heifers 8 and 12 weeks after housing (Table 1). Furthermore, CUS heifers tended to have lower foot lesion scores than CON heifers (P=0.063) 12 weeks post-housing.

Table 1 Influence of winter housing treatment on behaviour (mean ± s.e.) of pregnant dairy heifers

Behaviour	Concrete	Cushioned	Woodchip pad	P
Total stand	0.58 ± 0.011^{ax}	0.61 ± 0.018^{bc}	0.67 ± 0.011^{dy}	<0.001
Stand feeding	0.32 ± 0.006^{b}	0.35 ± 0.003^{a}	0.32 ± 0.009^{b}	<0.05
Stand in passageway	0.04 ± 0.007	0.06 ± 0.008	-	<0.05
Total lie	0.41 ± 0.011^{ax}	0.37 ± 0.009^{bc}	0.33 ± 0.011^{yd}	<0.001

Table 2 Influence of winter housing treatment on foot lesion scores (lsmeans ± s.e.) of pregnant dairy heifers

Inspection	Concrete	Cushioned	Woodchip pad	P
Pre-housing	1.1 ± 0.27	1.6 ± 0.27	0.7 ± 0.27	NS
Week 4	2.5 ± 0.45	1.4 ± 0.45	1.9 ± 0.45	NS
Week 8	5.7 ± 0.62^{x}	4.8 ± 0.62^{a}	2.7 ± 0.62^{yb}	<0.01
Week 12	5.6 ± 0.65^{x}	3.5 ± 0.65^{a}	1.6 ± 0.65^{yb}	<0.001

^{ab}, ^{cd}, ^{xy} Different superscripts indicate significant differences between treatments (P<0.05, P<0.01 and P<0.001 respectively)

Conclusion Similar to findings for cows on straw, claw lesion scores of heifers on the woodchip pad were lower than for heifers housed in cubicles. However, this improvement was not attributable to higher lying times by heifers on the pad. This suggests that the physical surface is more important in terms of claw lesions than the amount of time cows spend lying down. Moreover, where heifers had access to relief areas for standing indoors, lying was reduced but there was no adverse effect on foot lesion scores.

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Can behavioural studies be used to indicate depression in finisher pigs?

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Introduction Pigs can be physiologically and psychologically affected by their environment and by interactions with other animals. Whether the psychological effects are great enough to cause depression is not known. We hypothesised that should depression occur it would be most likely in victimised pigs. In this study we investigated what behavioural measures could be used to indicate levels of victimisation.

Materials and Methods 52 Large White/Landrace pigs, aged approximately 120 days, were kept in four pens of 13 ± 1 animals and had 1.3 m^2 of space allowance per animal. They were housed on straw and fed three times a day on liquid feed with feeder allowance of 0.3 m per pig. As the pigs had the greatest levels of interaction with their environment and with other pigs around feeding, pre- and post-prandial behaviours were analysed. The behaviours included posture and activity, such as lying, rooting and chewing. Scan sampling every 5 minutes was conducted for every pig and data collected for 24 hours per pig over 3 weeks until slaughter.

We generated a victimisation index (VI) for each pig, using the percentage of time the individual was recorded in particular postures or activities (Equation 1). We decided that negative or victimised behaviours included: being nosed or sucked which are aversive and inescapable behaviours directed towards them by another; and sitting, which has been used in previous studies as a negative welfare indicator in sows. These were weighted by -3 in the index. Rooting was chosen as a weakly positive behaviour and was not weighted as it is defined as a need and its prevalence demonstrates how much an animal interacts with its environment. To suck and nose another pig (victimising behaviour) was regarded as being less positive than being sucked or nosed was negative, so was given a weighing of +2. If a negative value was generated from the VI it indicated that an individual may be victimised, while a positive value suggests that the individual may be victimising others.

Equation 1 **VI** = (Being Nosed x -3)+(Being Sucked x -3)+(Sitting x -3)+(Rooting x 1)+(Sucking x 2)+(Nosing x 2)

Skin lesions on each pig were recorded in the home pen 3 times per week, as described by Moore *et al*. (1994), and stomach lesions were scored after the pigs were slaughtered using a 6-point scale obtained from ADAS Terrington. Relationships between the VI and skin and stomach lesions were examined using Spearman's Rank Correlation Coefficient on SPSS 11.5.

Results The VI for 14 pigs in pen 2 is shown in figure 1 (similar results were obtained from the other pens). Pigs 1, 4, 9 and 13, with VI values ranging from -23 to -4, are likely to have been victimised.

There was no correlation between the VI and the presence or severity of skin (P>0.05) and stomach (P>0.05) lesions.

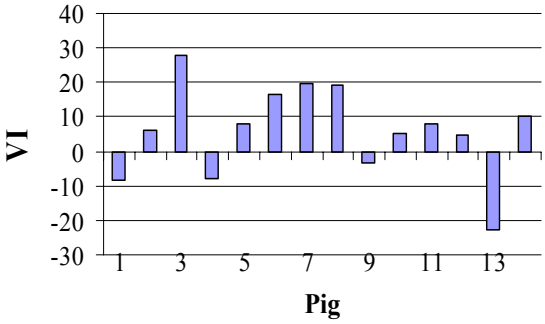

Figure 1 Victimisation Index for each pig in Pen 2

Conclusions The Victimisation Index can be used to identify pigs which are potentially being victimised by others; these animals could be investigated further for evidence of depression. Levels of fighting, displacement or mounting could have been more indicative of victimisation but the frequencies of these events were not great enough to be used in the index. The lack of correlation between the VI and skin lesions may have been because nosing and sucking behaviours were more similar to oral stereotypies than aggressive behaviours and were not causing skin damage. The lack of correlation between stomach lesions and the VI may be because stomach lesions are more influenced by diet than social factors.

Future work will include expanding the behaviours used in the index, and trying to relate other measures of poor welfare to the VI. Overall we need to increase the accuracy of the VI, which could be used to identify suitable candidates for further investigations into depression.

Acknowledgements E. Genever was supported by a BBSRC studentship. We thank Joe Staite for access to animals.

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The effect of teeth resection procedures on the welfare of piglets in farrowing crates

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Introduction Teeth resection is a method of controlling the injurious effects of the aggression displayed when newborn piglets fight to establish a teat order. However, recent European legislation discourages the practice (Commission Directive 2001/93/EC). The objective of this study was to assess the effect of clipping and grinding piglets' needle teeth, compared to leaving them intact, on the welfare of piglets in farrowing crates.

Materials and methods Six days pre-partum, 60 sows were assigned to one of three treatments. Litters had their teeth clipped (C), ground (G) or left intact (I) at birth. Piglet weights and facial lesions, scored according to severity, were recorded on days 1, 4, 11, 18 and 27 post-partum. Mouth lesions were recorded on days 1, 4 and 27. Instantaneous scan samples of piglet behaviour were carried out for 6h (08.00-10.00h, 11.00-13.00h, 14.00-16.00h) on days 1, 4, 8, 14, 21 and 26 at 5min intervals. One male and one female piglet per litter were chosen as focal animals and observed for 10mins each twice per day (morning and afternoon) on days 1, 5, 12, 20, and 26. Mortalities were recorded throughout lactation. Data were analysed by the Chi-Square test, analysis of variance and mixed procedure of SAS.

Results There was a significant interaction between treatment and day for facial lesion scores ($F=10.58$, $P<0.001$) (Figure 1). On all days the facial lesion scores of I piglets were higher than those of C piglets ($P<0.01$) and than those of G piglets on days 1, 4 and 27 ($P<0.001$). On day 18, G piglets had significantly higher facial lesion scores than C piglets ($P<0.05$). On all days fewer I than C and G piglets ($P<0.001$) and fewer G than C piglets ($P<0.001$) had mouth lesions (Day 1: $F=121.81$ $P<0.001$ C: 0.87 G: 0.60 I: 0.11 [proportion piglets with mouth lesions]; Day 4: $F=163.31$ $P<0.001$ C: 0.75 G: 0.45 I: 0.11; Day 27: $F=80.14$ $P<0.001$ C: 0.92 G: 0.70 I: 0.06). There was a significant interaction between treatment and day in the proportion of observations in which piglets were active ($F=2.11$, $P<0.05$), inactive ($F=5.02$, $P<0.001$) and sleeping ($F=2.87$, $P<0.01$). On day 21, I piglets were active in more observations than G piglets ($P<0.05$) (Figure 2). G piglets were inactive in more observations than C and I piglets on day 4 ($P<0.05$) and than I piglets on day 26 ($P<0.05$) (Figure 3). On day 14, G piglets were sleeping in fewer observations than C piglets ($P=0.05$) and on day 26, in fewer observations than both C and I piglets ($P=0.05$) (Figure 4). There was no effect of treatment on focal piglet behaviour through lactation ($P>0.05$). There was a tendency for a larger proportion of I than C piglets to die due to overlying ($F=2.68$ $P=0.08$ C: 0.03 G: 0.07 I: 0.09 [proportion piglets in litters that died due to crushing]). There was no effect of treatment on piglet weights through lactation ($P>0.05$).

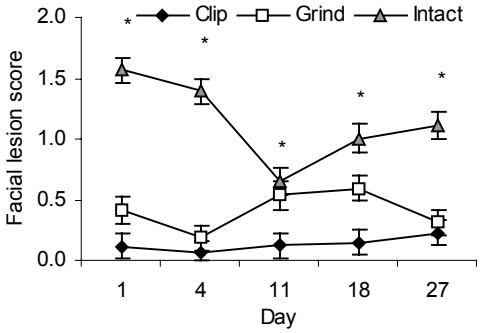

Figure 1 Effect of teeth resection method on facial lesion scores

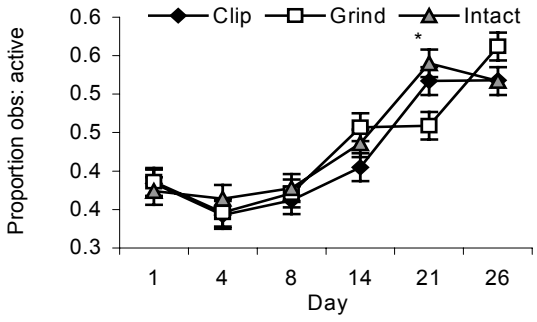

Figure 2 Effect of teeth resection method on the proportion of observations of active behaviour

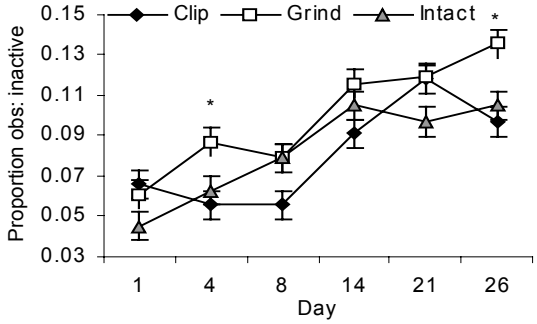

Figure 3 Effect of teeth resection method on the proportion of observations of inactive behaviour

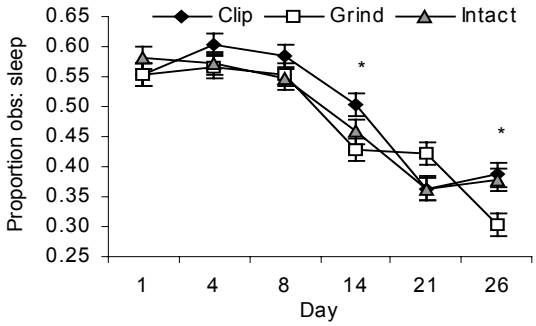

Figure 4 Effect of teeth resection method on the proportion of observations of piglets sleeping

Conclusion When piglets are housed in farrowing crates, leaving their teeth intact cannot be recommended due to a tendency towards higher mortality. Clipping was more successful in eliminating the problem of facial injuries but injuries to the mouth caused by clipping were probably associated with infection, evidenced by increased sleeping. Grinding reduced piglet facial injuries relative to leaving the teeth intact and reduced mouth injuries relative to clipping.

The route of absorbed nitrogen to milk protein

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Although the efficiency of transfer of N is higher in dairy cows than in growing ruminants, there is still room for improvement as only approximately 30% of the ingested N is recovered in milk protein. The remainder is excreted in faeces (30%) and urine (40%). This review will focus on the metabolic utilisation of the digested N fraction: where in the body is this N partitioned between anabolic (milk protein, tissue growth) and catabolic (urine) fates and what factors influence its efficiency of use?

Portal-drained viscera. As for other nutrients, with the exception of lipids, N metabolites are absorbed from the lumen of the gut across the gut wall into the vascular drainage that forms the tributaries of the portal vein, the main blood vessel supplying the liver. Blood flow in the portal vein of lactating dairy cows averages 1500 to 2000 L/h. Energy intake is believed to be the major regulator of this flow. Nitrogen is mainly absorbed from the digestive tract as ammonia and free amino acids (AA), with apparently digested N partitioned between AA (56%) and ammonia (59%). So, how can the amount of N absorbed as ammonia and AA exceed the amount of N apparently digested? This is due to the important return to the gut of urea-N, either via saliva or directly through the gut wall. Indeed, in dairy cows, return of urea-N to the gut was equivalent to 30% of the amount of N digested. Net appearance of AA in the portal vein represents the true absorbed AA minus those either oxidised by the gut tissues or incorporated into endogenous secretions that not reabsorbed and consequently lost in faeces. Data are limited on the impact of these processes on both the quantities and pattern of AA presented to the liver. Recent studies have shown that for the essential AA (EAA), there are significant losses of the branched chain AA (BCAA) through oxidation, with the magnitude influenced by metabolisable protein supply. In addition, non-reabsorbed endogenous secretions reduce Thr availability to the rest of the animal. Overall, however, the AA absorbed will relate to the amount and profile of metabolisable (or digestible) protein, which is influenced by factors such as rumen undegradable (bypass) protein and the synchrony of rumen availability between energy and protein.

Liver. The portal vein enters into the liver where it supplies more than 85% of the blood flow. With diets commonly fed to dairy cows, all the ammonia absorbed into the portal vein is removed by the liver. From the subsequent ammonia detoxification and from AA catabolism, the liver produces urea. This constitutes a huge flux, as hepatic ureagenesis represents approximately 85% of the amount of N digested. Across the liver, the removal of EAA appears to be distributed between two classes: those with little, if any, removal (BCAA & Lys), and those that have substantial extraction (His, Met, Phe & Thr). In dairy cows fed to requirements, removal of these latter AA will vary between 25 and 50% of the net portal absorption. However, this removal can be reduced if protein supply is limited. Hepatic removal of AA does not systematically translate into catabolism: the liver synthesis of export plasma proteins can account for up to 20% of Phe removal. The challenge resides in defining how much of this removal 1) is required for obligatory functions (e.g. synthesis of key metabolites and export proteins, non-regulated catabolism) and 2) controls or reacts to peripheral tissue utilization.

Mammary gland. For the BCAA and Lys, post-liver supply exceeds mammary uptake (by up to 30%), which itself exceeds the amount secreted in milk protein (also by 30%). These AA therefore are catabolised by peripheral tissues, including the mammary gland. For the BCAA, catabolism across the mammary gland can be reduced if supply becomes limited. In contrast, post-liver supply of His, Met and Phe is approximately equal to both mammary uptake and incorporation into milk protein, indicating little, or no, catabolism, of these AA by peripheral tissues, including the mammary gland. This close link raises the question: "Does the liver regulate supply of these AA to the mammary gland, therefore controlling milk output, or merely remove AA in excess of anabolic needs?" The answer to this question will be important in determining why and how AA are partitioned between anabolism and catabolism and how this could be altered.
Although Lys is often considered a limiting AA with corn-based diets fed to high yielding cows, it is intriguing that it is taken up in excess by the mammary gland. Recently, the excess Lys removal has been shown to support N (and probably C) requirements for non-essential AA synthesis (NEAA) within the udder. This role is similar to that proposed previously for the BCAA and helps explain the source of N for the synthesis of NEAA as mammary uptake of NEAA from blood is insufficient to match output in milk protein.

Practical implication. With a decreasing N supply, the ratio of milk-AA to absorbed AA is increased, as the reduction in milk output is much smaller than the reduction in protein supply because catabolic losses are reduced. Thus, schemes that predict milk protein output should not use fixed conversion factors of supply to output, as these will be higher with lower supply. Indeed, when milk output is close to maximal, the returns from extra AA supply are often marginal. Therefore, a better route than achieving maximal output, in terms of both economics and use of natural resources, is to balance the supply of individual AA to the needs of the dairy cow, based on a good understanding of the various metabolic controls that exist within the animal. Such an approach allows a reduction in N intake without a major impact on milk production, but with a substantial lessening of urinary N excretion and negative environmental impacts.

Impact of splanchnic metabolism on nutrient supply to peripheral tissues - energy

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Introduction Rumen fermentation and splanchnic metabolism affect the relationship between the chemical composition of the feed and the nutrients available to the mammary gland and other peripheral tissues in the dairy cow. Conventional feed evaluation systems don't allow the nutritionist to design diets based on the demand for specific nutrients, but primarily base predicted animal responses on the energy content of digested organic matter. In a nutrient based feed evaluation system (NBFE) the chemical composition of the feed and monitoring of ruminal variables in real time can be used as input to simulation models describing fermentation and intermediary metabolism. The aim of the system is to analyse/evaluate dietary adjustments according to specific metabolic needs of the dairy cows under specified physiological conditions. It's mandatory that NBFE systems account for all major nutrient fractions absorbed and metabolised in the dairy cow. Short-chain fatty acids (SCFA) have been particularly troublesome in this respect because it generally has been assumed that a large proportion of ruminally absorbed SCFA is metabolised by the rumen epithelium and therefore is not available to the liver or peripheral tissues. The aim of this presentation is to review the interrelations between ruminal production, portal absorption, and peripheral availability of SCFA in the ruminant and to discuss how the metabolism of SCFA might be incorporated into future NBFE systems.

Separating microbial and rumen epithelial metabolism of SCFA Numerous studies have shown that SCFA infused into a normal functional rumen of sheep or cattle cannot be accounted for in the portal blood. There are at least three different explanations to this problem 1) microbial use of part of the SCFA, 2) metabolism of SCFA by the epithelium during absorption (first pass sequestration), and 3) metabolism of arterial SCFA or SCFA metabolites by the portal drained viscera (PDV; second pass sequestration) masking the unidirectional flux from the lumen to the blood. With regard to SCFA, all three explanations are involved. Data shows that SCFA are metabolised by rumen microbes, that especially butyrate and valerate are metabolised by the rumen epithelium and that PDV uptake of acetate and 3-hydroxybutyrate accounts for a large proportion of the whole body metabolism and therefore masks the unidirectional lumen to blood flux when this is estimated from the net portal flux.

The metabolic window of the rumen epithelium Various experiments have been carried out in vivo to study the metabolism of fatty acids with various chain length. The rumen epithelium has an affinity for butyrate and valerate whereas considerably lower proportions of acids with a longer chain length is taken up by the epithelium during absorption. The uptake of absorbed propionate is around 10% and acetate is most likely not taken up by the epithelium, but probably produced in small amounts by the epithelium. The rumen epithelial metabolism of butyrate and valerate apparently compete for the same pathway and the limited metabolic capacity of the epithelium implies that increased absorption of just one of these SCFA increases the portal absorption of both. The rumen epithelial metabolism of SCFA other than valerate and butyrate is not largely affected by butyrate.

Hepatic SCFA metabolism The liver takes up 90% or more of the ruminally absorbed propionate under most conditions, but excessive loads of propionate or butyrate are followed by increased splanchnic release of propionate. Increased ruminal butyrate absorption is therefore not only ketogenic by providing substrate for ketogenesis, but it may also affect glucose homeostasis by shifting propionate metabolism from the liver to peripheral tissues. In experiments with steers it was found that increased ruminal butyrate absorption increased the splanchnic propionate release from 8 to 22% of the ruminal absorption rate. SCFA with a chain length longer than butyrate are taken up more efficiently by the liver than are propionate and butyrate. It's noteworthy that the primary interactions between SCFA in the liver are between propionate and butyrate, whereas propionate metabolism is less affected by longer chain SCFA.

Integrating SCFA metabolism in feed evaluation systems No feed evaluation system accounts for SCFA availability or metabolism despite the fact that SCFA accounts for up to 50% of the digestible energy. At this point the multicatheterised dairy cow model and basic knowledge on SCFA absorption and metabolism allow us to study both the quantity and composition of SCFA produced in the gastrointestinal tract. However, a model/system for practical use has to be able to either measure or predict a number of critical rumen variables in order to satisfactorily describe the metabolism of SCFA. One attractive strategy to overcome these obstacles could be to base the NBFE system on a combination of model predictions and monitoring ruminal parameters in real time by means of a rumen bolus equipped with radio transmission.

Conclusion Improvements in feed evaluation systems for dairy cows depend on a system that describe or monitor the complex biology of rumen fermentation as well as the intermediary metabolism. It might be fruitful to attempt a combination of real time monitoring and dynamic simulation models. The interactions observed between propionate and butyrate metabolism in the liver suggest that splanchnic SCFA metabolism might deserve considerable attention for instance in the transition dairy cow. She may have an insufficient metabolic capacity in the rumen epithelium and could therefore be vulnerable to increased butyrate loads.

Endocrine functions of splanchnic tissues of cattle

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Introduction The splanchnic tissues of cattle are comprised of the portal-drained viscera (PDV; the gastrointestinal tract, pancreas, spleen, and associated adipose) and the liver. The PDV and liver act as an anatomically and functionally integrated unit which monitors the flow of nutrients from the diet and integrates their metabolism with body requirements. This integration occurs via a myriad of orchestrated metabolic, neural, and endocrine signals which through interplay with the brain ultimately determine appetite, digestive function and the balance between nutrient availability and use for productive function. This review will focus on specific aspects of endocrine metabolism by these tissues in cattle, and consider their potential impact on nutrient intake during lactation.

Insulin Measurements of net insulin flux across the PDV can be obtained using catheterization procedures enabling the measurement of venous-arterial concentration difference and blood flow. These measurements are invariably positive, representing pancreatic release into blood, less the amount removed from arterial blood by the total PDV. Net PDV release of insulin is typically pulsatile, thus frequent sampling is preferred. The liver is a major site of insulin clearance from blood, accounting for as much as 2/3, or more, of net PDV release, therefore liver removal is a critical determinant of total splanchnic release and arterial concentration of insulin. Across a number of observations in growing cattle, net PDV and splanchnic release of insulin, and thus arterial concentration, increases with greater intake. Greater intake will increase glucose supply from the liver, and a positive relationship between glucose supply and arterial insulin concentration is often observed. In addition to glucose, numerous other absorbed nutrients influence splanchnic insulin release and arterial concentration, including certain fatty and amino acids. For example, chronic mesenteric vein infusion of both alanine and arginine increased arterial insulin concentration in maintenance fed cattle. For arginine, this was a consequence of increased PDV release. In the case of alanine infusion, PDV release of insulin was reduced, but an even greater reduction in liver removal led to an increase in splanchnic release. These observations emphasize that the regulation of peripheral insulin concentration is achieved through orchestrated changes in both pancreatic release and liver removal. In addition to direct effects of absorbed nutrients on insulin metabolism, a number of peptides of gut origin are now known to influence insulin secretion by the pancreas. These so called 'incretins' include glucose-dependent insulinotrophic polypeptide (GIP) and glucagon like peptide-1 (GLP-1), which are released by the gut in response to increased luminal nutrient concentration, but little is known about their functions in cattle. In addition to affects on nutrient use, insulin coordinates both short- and long-term appetite and nutrient balance through effects on neuropeptide Y in the hypothalamus.

Glucagon As for insulin, net PDV release and arterial concentration of glucagon increase with greater intake in growing cattle, and glucagon secretion from the pancreas is regulated by a number of nutrients absorbed from the diet, including propionate and certain amino acids. As for insulin, liver removal is an important determinant of peripheral glucagon concentration. During mesenteric vein alanine infusion increased arterial glucagon concentration was due both to an increased net PDV release and decreased liver removal. Glucagon was named for its effects on glucose synthesis, but it is also an important regulator of urea synthesis and splanchnic glucagon release increases when excess protein is fed. Pancreatic glucagon is one of many products of proglucagon processing which have been found to be released by the PDV. Many antibodies used to measure glucagon cross react with more than one proglucagon product released from the gastrointestinal tract, and in growing cattle the anterior mesenteric-drained viscera, which does not include the pancreas, releases more than half the immuno reactive glucagon released by the total PDV.

Gut peptides The glucagon 'family' of peptides includes the gut glucagons (glicentin, oxyntomodulin), GLP-1 and glucagon-like peptide-2 (GLP-2). The active form of GLP-1 (7-36 amide) has been shown to inhibit intake through direct effects in the hypothalamus. Other gut peptides which have been implicated as regulators of intake include cholecystokinin-8 (CCK-8) and peptide YY (PYY), and like GLP-1 these peptides have inhibitory effects on gut motility, as well as inhibitory effects on intake via hypothalamic actions. While their effects on gut function are well documented, it is not certain whether their effects in the hypothalamus are endocrine or paracrine responses. There is evidence that an increase in gut CCK release may be responsible for the decrease in intake which is often observed in lactating dairy cows fed fat. However, in lactating dairy cows abomasal vegetable oil infusion decreased intake with no effect on arterial concentration or net PDV release of CCK-8, but did increase net PDV release and arterial concentration of GLP-1 (7-36) amide. Considering the effects demonstrated in other species, it is likely that PYY plays a role in regulating intake and gut functions of lactating dairy cows as well.

Liver In addition to modulating circulating levels of hormones from the PDV, the liver also synthesizes insulin-like growth factor 1 (IGF-1), which like insulin is sensitive to changes in body energy status. However, the rate of release is so low relative to blood flow that net IGF-1 flux across the liver has not been measurable using immunoassays.

Conclusion The recent discovery of ghrelin, a gut peptide shown to regulate appetite and growth hormone secretion, suggests there is still much to learn about the complexities of splanchnic endocrine functions and their roles in determining nutrient intake and use. While there are potentially many practical applications which may develop from our understanding of splanchnic endocrine biology, there has been little research in dairy cows.

Quantitative aspects of splanchnic metabolism in the lactating ruminant.

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Introduction. Rations for dairy cattle are currently balanced to meet needs for energy, protein, vitamins, and minerals. While individual vitamins and minerals are considered, energy and protein terms are generally treated in aggregate, i.e. requirements have not been defined for the nutrients comprising those terms. A number of examples can be drawn from the literature demonstrating that milk yield and composition can be affected by varying the type of energy fed even when diets are isocaloric. While progress has been made towards the goal of balancing dairy rations to meet individual amino acid needs, we still have not achieved the level of sophistication realized for other commercial species. Although significant efforts have been undertaken to describe ruminal metabolism, ruminal output predictions have been largely channeled into aggregated descriptions of postabsorptive metabolism that assume constant fractional conversions of energy and protein to milk. If further progress is to be made, ruminal predictions must be matched with postabsorptive equations that track the key metabolites through that system to the tissues of interest. In that manner, the effects of individual metabolites on endocrine status and tissue metabolism can be more accurately reflected. To succeed in this latter effort, a quantitative understanding of the post-absorptive tissues is required. The splanchnic tissues are critical components of the postabsorptive system as they mediate absorption of nutrients and play a role in regulation of metabolite availability to the remaining postabsorptive tissues. The pertinent questions related to their metabolism are: 1) what proportion of each metabolite presented to the tissue is utilized by the tissue, and 2) is the proportion used constant across diets and physiological states?

Portal-drained viscera. Efforts to provide a quantitative description of PDV metabolism have been hampered by the complexity associated with making measurements of such metabolism. Initial observations of volatile fatty acids (VFA) use by Bergman and Wolff (1971) and essential amino acids (EAA) use by Tagari and Bergman (1978) suggested that the PDV catabolized significant proportions of acetate, propionate, butyrate, and EAA during absorption. However, subsequent work has demonstrated that while the PDV extensively catabolize butyrate, catabolism of acetate and propionate is minor with most of that catabolism occurring from arterial blood (Kristensen et al., 2000). Baldwin and McLeod (2000) have provided some additional in vitro information regarding the kinetics of substrate utilization by the ruminal epithelium. Although these observations are useful, they were not designed to explore the kinetics of the full tissue bed.

The EAA have also been observed to be largely utilized from blood supplies with little use during the absorptive process (MacRae et al., 1997). We have recently explored the kinetics of amino acid (AA) absorption and metabolism by the PDV in lactating dairy cows. This work has suggested that EAA utilization by the PDV is linear with respect to the total supply with no apparent discrimination among arterial and absorbed supplies, and that the apparent affinities for EAA are relatively low as compared to the udder. A significant proportion of the EAA removed by PDV are apparently utilized to synthesize endogenous proteins that are lost at the ileum.

To this time, there have been no attempts to construct an integrated PDV model. While we have some understanding of the kinetics of AA metabolism, we must assume that fixed fractions of the VFA traversing the PDV are utilized. A fuller understanding of glucose, lactate, and long-chain fatty acid metabolism is still needed as well as exploration of potential interactions among energy and nitrogen metabolism.

Liver. Considerably more hepatic work has been completed with at least 2 models of energy metabolism having been constructed (Danfaer, 1994; Freetly et al., 1993) and one model integrating energy and AA metabolism (Hanigan et al., 2004). Hepatic affinity for propionate, butyrate, and ammonia was observed to be very high assuring clearance of the vast majority of these substrates from portal blood. The liver generally produces acetate and ketones when the animal is in the lactating state largely resulting from removal and partial oxidation of LCFA. Removal of LCFA was linearly related to supply and thus influenced by endocrine regulation of adipocyte lipid storage. Lactate removal ranges from positive to negative depending on gluconeogenic signals. Thus diets varying in glucogenic precursor supply would be expected to affect not only the production of ketones but also the production of acetate and utilization of lactate.

Essential amino acid removal by liver appears to be primarily a linear function of total supply to the tissue with relative affinities similar to that of the PDV with the exception of arginine where the hepatic affinity is several times greater than the PDV affinity. Increased glucogenic signals result in hepatic removal of non-essential AA (NEAA). However, little work has evaluated the effect of glucogenic signals on EAA kinetics and thus potential impacts on EAA flux across the tissue cannot be ruled out at this time.

Practical Implications. Glucogenic precursor supply can significantly affect endocrine status and thus splanchnic release of glucose, acetate, lactate, ketones, and the NEAA. Although the relative affinities of the splanchnic tissues for EAA are low as compared to the udder, net clearance on a daily basis represents approximately 2/3 of the net supply to the animal due largely to recycling of AA back to the tissue bed. This could be significantly reduced by simply stimulating removal and use by the udder as splanchnic affinities are much lower than mammary affinities. Additionally, the EAA composition of absorbed protein is significantly modified by these tissues due to differing affinities for each of the AA. The extent of that modification is not a fixed constant but rather a function of several factors including milk yield. Our current feeding systems could be improved by inclusion of a more accurate consideration of the metabolic complexities of the splanchnic tissues.

Immunological strategies to boost reproductive efficiency in sheep and cattle without adverse effect on animal welfare

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Introduction The concept of using immunological strategies to boost reproductive performance in sheep and cattle is far from new, with products such as Fecundin®, which involved active immunisation against the weak androgen, androstenedione, having been released nearly 20 years ago. However, whilst effective in sheep, immunisation against androgens was not effective in inducing multiple ovulation in cattle (unpublished observations), in which the natural rate of twinning is low (<4%). The purification of inhibin in the late 1980's and the subsequent elucidation of its role in controlling follicle stimulating hormone (FSH) release from the pituitary represented an alternative means to increase prolificacy in domestic ruminants. Intense research effort throughout the 1990's utilising active inhibin immunisation showed that while this approach was quite successful in sheep, results in cattle were less promising due to the extreme variability of the response obtained both between animals and within a single animals across successive cycles. Further, while numerous studies have shown that with correct identification and management production of twins in cattle can lead to significant economic gains, the possibility of more than two young clearly raised welfare concerns for both sheep and cattle in terms of dystocia and post-natal welfare of both the mother and her offspring. Over recent years, however, continued research into the control of ovarian follicle development in ruminants has suggested alternate immunological strategies that could be used to modulate prolificacy in a more reliable and controllable manner.

Material and methods As FSH is the main hormone controlling ovarian follicle development, it is logical that modulation of this pituitary gonadotrophin will lead to an increase in ovulation rate. We reasoned that the most likely explanation for the variability in the ovarian response to active inhibin immunisation in cattle was the existence of an acute pattern of follicle dominance in cattle throughout the luteal phase. Thus boosting animals at the wrong stage of a follicular wave could lead to a low response if a dominant follicle was present or an overstimulation if the boost coincided with follicular recruitment. This problem, allied with a more general difficulty in obtaining repeatable acute titre responses to immunisation in cattle meant that active inhibin immunisation was unlikely to succeed as a means of inducing twin ovulations in cattle. We reasoned that what was needed was an immunisation protocol which would combine the acute and controllable nature of passive immunisation, so that animals could be treated at the optimum stage of a follicular wave, with the long-term titre response of active immunisation. Using sheep with ovarian autotransplants as a model system, such a protocol was developed which involved an acute bolus injection of inhibin antiserum followed by supplementary daily injections. This protocol was observed to induce increased FSH, multiple follicle develop and multiple ovulation (Campbell & Scaramuzzi 1995). Using these data as a basis, a similar protocol was applied to cycling Holstein beef cross heifers with the initial bolus of antiserum being injected on Day 2 of the cycle, with supplementary injections on Days 3-8. Luteal regression was induced on Day 7 by injection of prostaglandin and the pattern of follicle development and ovulation followed by transrectal ultrasound.
It is now clear that the action of the pituitary gonadotrophins in controlling ovarian function is modulated at a cellular level by local paracrine and autocrine factors. Recent research has shown that the oocyte is the source of a number of these factors, including growth differentiation factor 9 (GDF-9) and bone morphogenic proteins 6 and 15 (BMP-15). As a result of the observation that animals heterozygous for naturally occurring mutations in the BMP-15 gene (FecX) have increased ovulation rates, studies in New Zealand have examined the effect of active immunisation against GDF-9 and BMP-15 on ovarian function and ovulation rate in sheep (McNatty *et al.*, 2003).

Results The ovarian response to passive inhibin immunisation varied according to the antibody titres obtained. In one trial, relatively low titres resulted in an increase ($P<0.001$) in the number of medium sized follicles in immunised heifers (n=8) but did not lead to an increase in ovulation rate. However, increasing the dose of antiserum in a second trial resulted in all immunised animals (n=7) developing 2-3 dominant follicles during the first follicular wave and 6/7 animals responded to prostaglandin and ovulated. Twin ovulations were observed in 4/6 heifers and one of the other two remaining animals had two dominant follicles, but only a single ovulation.
The results of BMP-15 and GDF-9 immunisation similarly showed differential response according to titre, with higher titres resulting in disruption of folliculogenesis whereas lower titres resulted in multiple ovulation, with around half the animals having ovulation rates greater than 4 (McNatty *et al.*, 2003).

Conclusions The results of these recent studies suggest alternate strategies whereby prolificacy in domestic ruminants could be enhanced in a more controllable and repeatable manner by modulating FSH more acutely or by altering expression of intra-ovarian modulators of ovarian function. The challenge that remains, however, is to find ways to control antibody response and determine if live birth rates can be increased utilising these strategies.

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Suppression of sexual behaviour in farm animals by GnRH immunization and the implications for productivity and welfare

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The secretion of sex steroid hormones by the gonads of male and female farm animals improves performance, food conversion efficiency and meat content of carcass, but can adversely affect behaviour and meat quality. In particular, androgens produced by males induce aggressive and sexual behaviour, which make it difficult to manage pubertal bulls during the finishing stage. Castration, depending on age of male, can cause temporary stress but it results in decreased productivity of 7-10%, reduced feed conversion efficiency of 3 to 5%, reduced carcass weight and increased fat deposition in the carcass. Pubertal boars and bulls also produce meat that is less desirable from the consumer's perspective due to boar taint and toughness of bull beef. The expression of recurrent periods of transient oestrous behaviour in beef heifers following puberty and cull cows can cause managerial problems and result in up to 15% of beef heifers in US feedlots being pregnant. This causes loss of productivity and increased stress if pregnant animals remain in the feedlot. Thus, the suppression of recurrent oestrous periods in beef heifers is desirable provided performance is not compromised. Ovariectomy is difficult to perform, causes stress and reduces performance by 3-5%, while the use of progestogens to suppress oestrus is prohibited by legislation in the EU. Thus, alternative methods that are conducive to good performance, meat quality and welfare have been sought. The most promising alternative approach developed over 20 years ago is to immunocastrate animals by immunizing them against gonadotrophin releasing hormone (GnRH), thereby suppressing LH and FSH secretion. This causes temporary anoestrus in females or reduced androgen secretion, testes size and aggression in males.

GnRH is a decapeptide and is not inherently immunogenic. Hence, it is either chemically conjugated to a carrier immunogenic protein such as human serum allumin or ovalbumin or is made immunogenic using a recombinant fusion protein where specific hormone epitopes are incorporated into the sequence of the immunogenic protein (ovalbumin – GnRH). Primary and booster immunizations are required to produce biologically active antibody titres. Immunization of prepubertal bull calves at 4-7 months of age reduces LH and testosterone concentrations in serum compared with intact bulls. It also reduces testes size, decreases aggressive and sexual behaviour, has no adverse effect on performance or carcass weight, and does not adversely affect longissimus dorsi muscle area, marbling score or backfat thickness compared with controls. The age at which bulls are immunocastrated is important. Immunization before 4 months is less effective while immunization of post pubertal bulls reduces testes size, testosterone and growth rate significantly. Thus, immunization of young beef bulls at 4-7 months of age gives bull performance but steer behaviour and meat quality, thereby improving their welfare status. However, effects on organoleptic quality of meat need to be determined.

Immunization of post-pubertal heifers against GnRH reduces LH and FSH concentrations, induces anovulatory anoestrus for 70 to 80 days, suppresses recurrent ovarian follicular waves, decreases serum oestradiol concentrations, reduces average daily gain during anoestrus without an overall negative effect on final carcass weight. Immunization of prepubertal heifers at 8 months of age, before puberty, with multiple booster immunizations prolonged anoestrus and delayed the onset of puberty for 175 days compared with controls, but average daily gain was decreased from 0.77 to 0.68kg per day in GnRH immunized heifers during anoestrus. Thus, GnRH immunization in heifers suppresses oestrous behaviour and recurrent follicular waves, decreases oestradiol during anoestrus and the effect on performance depends on length of anoestrous period induced and whether or not animals are cyclic at the start of treatment.

The major concern in using young boars for meat production is boar taint which decreases the eating quality of pork. It is caused by skatole and the androgen metabolite androsteneone. The increase in slaughter weight in some countries has resulted in increased risk of boar taint. The use of GnRH immunization is now a practical alternative to castration in boars because a commercial vaccine has been developed. The vaccine can be administered at 8 and 4 weeks before slaughter. Testes size, testosterone concentrations and boar taint (concentrations of skatole and adrosteneone) were decreased and not different from castrate controls ($p>0.1$). Average daily gain was improved ($p<0.05$) compared with controls but backfat thickness was also slightly increased compared with boars but was reduced compared with castrate controls. Thus, a well-tolerated vaccine that decreased fighting lesions at slaughter allows boars to be slaughtered at heavier weight without the problem of boar taint, but with improved welfare and meat quality compared with control boars.

The immunization of farm animals against GnRH is now a practical and beneficial proposition for animal welfare and meat quality in pork production. There are technical hurdles to be crossed in the development of practical commercial methods to decrease aggression, improve meat quality and maintain the performance of finishing beef bulls. The registration requirements, the costs involved and the uncertainty of consumer reaction to endogenous manipulation of hormones will impede such developments in cattle in the EU. In the US, the requirement for a repeatable homogenous chemical preparation from batch to batch eliminates chemical conjugation because it is virtually impossible to obtain the identical compound repeatedly with current methods used. The adoption of new technology in food production will lag behind that used to control diseases in humans, even where welfare and food quality benefits are clear cut due to the uncertainty of consumer reaction to its use in the food chain.

Natural products for manipulating rumen fermentation

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Background

Legislators in Europe have moved to prohibit the use of growth-promoting antibiotics in animal feeds from the end of 2005. This decision was based on public and political concerns that the heavy use of antibiotics in general can give rise to transmissible resistance factors which can compromise the potency of therapeutic antibiotics in man. Growth promotion was a clearly avoidable use. Thus, alternative means are being sought to modify ruminal fermentation to benefit production efficiency and product quality. Natural plant products offer a wide range of potential as manipulating agents.

Many secondary compounds are produced by plants as natural protection against microbial and insect attack. Some are toxic to animals too, but others may not be, indeed many have been used in the form of whole plants or plant extracts for food or medical applications in man. The potential of two classes of plant secondary compounds, namely essential oils and saponins, as feed additives in ruminant production is described here, along with the early results of a Framework 5 project, RUMEN-UP (http://www.rowett.ac.uk/rumen_up/), whose aim is to find novel plant materials that may be useful as feed additives for ruminants.

Essential oils

Essential oils are steam-volatile or organic-solvent extracts of plants, many of which have been used traditionally by man for the pleasant odour of the essence, or their flavour, or for their antiseptic and/or preservative properties. They comprise mainly cyclic hydrocarbons and their alcohol, aldehyde or ester derivatives. Essential oils are marketed by a number of companies in Europe as feed additives for ruminants. Our experiments at the Rowett Research institute have focussed on one commercial blend of essential oil compounds and its component oils (EO; CRINA Ruminants, Akzo Nobel Surface Chemistry, Hertfordshire, UK). *In vitro* studies indicated that three main groups of bacteria involved in protein and starch breakdown are inhibited by EO. The most sensitive group comprised two species of the so-called 'hyper-ammonia-producing' (HAP) bacteria, *Clostridium sticklandii* and *Peptostreptococcus anaerobius.* The second group was *Ruminobacter amylophilus*, a starch-fermenting, proteolytic species. The third group, the *Prevotella* spp., are involved in all steps of protein breakdown to ammonia.. Certain individual oils in the mixture appeared to be more strongly associated with inhibitory effects than others, suggesting a specificity of action of different oils on different species.

Saponins

Bacterial protein breakdown is extensive in the rumen and carried out mainly by ciliate protozoa. Avoiding the engulfment and digestion of bacterial cells by protozoa would be a manipulation strategy which would have a great impact on microbial protein flow from the rumen in most ruminants throughout the world. Saponins-containing plants or plant products have a great potential for achieving the suppression of rumen ciliate populations. The effectiveness of some saponins-containing plants does not persist for a long period of time, because the active saponins are hydrolysed by bacteria to the less effective sapogenins. However, other plants, such as *Enterolobium cyclocarpum*, retain their effectiveness for at least several weeks. The difference between persistent and more transitory antiprotozoal saponins is not yet known.

RUMEN-UP

The aim of the overall project is to develop new plants or plant extracts as dietary supplements for ruminants. Plant materials (500 specimens) were collected from botanical and industrial collections, and were evaluated *in vitro* for their ability to prevent lactic acid formation, bloat, methane formation and to decrease protein breakdown. The samples were also investigated to ensure that potentially useful samples had no detrimental effect on the other basic functions of the fermentation, such as fibre digestion and volatile fatty acid production. At least 25 samples were of potential usefulness, of which 8 are in the process of further development.

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Alternative approaches to chemotherapy in disease control: the case of parasitism in ruminants

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Introduction The twentieth century has seen the emergence of chemotherapy, which has represented one of the most powerful tools to fight pathogenic agents as various as bacteria, fungi and protozoan or metazoan parasites both in the field of human and veterinary medicine. However, at the beginning of this new century, it is obvious that chemical treatments are now facing limitations. The case of gastrointestinal nematode of ruminants (GIN), has been chosen as an illustration of this novel situation and consequently, the enforced "evolution" in methods of disease control. Gastrointestinal parasitism remains a main pathological constraint associated with the breeding of ruminants. The usual mode of control of these diseases is represented by the repeated use of anthelmintics (AH) to maintain parasitism under a level that does not penalise animal health and welfare and comprises with objectives of production. However, this quasi exclusive reliance on chemotherapy is nowadays strongly questioned by the constant and widespread diffusion of AH resistance in nematode populations. The increasing concern of consumers on the use of chemicals in farm industry and for animal welfare has also been considered since it leads to a strengthened regulation on the use of treatments in farm animals and to a renewed interest for less intensive systems of production, such as organic farming. These various reasons explain the current demand for alternative methods to complement or replace chemotherapy. Such methods can be classified according to 3 principles.

1 To minimise infection with pathogens is one of the main principle sustaining sanitary prophylaxis. In the case of GIN in ruminants, since pasture is the main source of infection, this principle mainly relies on various methods of grazing management to reduce the contact between susceptible hosts and large amounts of infective larvae present on the grass. Less intensive systems of production with lower stocking rates contribute towards diluting the parasites in the environment and limiting infections. Alternate or simultaneous grazing between different host species have also been identified for long to reduce the risk represented by pastures, based on the relatively strict specificity of nematodes for one host. Substantial reductions of pasture contamination can also be achieved by use of biological mode of control, such as nematophagous fungi (Larsen, 1999).

2 To improve the host response against parasites. As for many other pathogens, vaccine represents the most obvious alternative to chemotherapy. It is known that the ruminant immune response can limit the establishment of infective larvae and modulate the biology of worms. Based on the concept of hidden antigen, recent promising advances have been acquired on possible vaccination of sheep against *Haemonchus contortus*, one of the most pathogenic nematode species (Schallig, 2000). However, in the case of GIN in ruminants, this approach still appears a long term solution as it remains impeded by the need for a multivalent antigen candidate. The genetic selection of lines and/or breeds of small ruminants expressing a natural or acquired resistance to parasites represents another way to improve the host response against GI parasites. Programmes conducted in many countries have shown that, depending on the criteria of selection, the heritability values ranged between 0.2-0.3 and that no negative correlation occurs between the resistance status and production parameters. However, interrogation still remains on the association between the resistance to nematodes and the response to other pathogens as well as on the relationship between host resistance and resilience. Last, to a large extent, nematode infection of the digestive tract can be considered as a nutritional disease since the main pathophysiological consequences interfere with the host digestive physiology. *A contrario,* a large bulk of studies have demonstrated that manipulation of the host diet, in particular through the protein component, can strongly improve the host resistance and resilience (Coop & Kyriazakis, 1999).

3 To eliminate parasites in the host. The ability to eliminate the pathogens within the hosts by use of active therapeutic agents is the third option to regulate parasitism. Despite their current limits, chemical treatments still represent an attractive and, usually, efficient solution. However, the use of any chemical drug has nowadays to take into account 2 objectives, which appear somehow paradoxical: to kill the pathogens ***and*** to avoid the development of resistance to drugs. These combined tasks assign a more pertinent use of drugs, switching from the concept of maximal protection to that of optimal coverage, supported by a more rational and selective use of AHs (Hoste et al, 2002). Moreover, the need to eliminate parasites in the host has stimulated a growing interest for new (rediscovered ?) methods of control. For example, in ruminants, a promising option is represented by the potential antiparasitic effects associated with plant secondary compounds and tanniferous plants (Athanasiadou et al , 2003).

Conclusions: The previous experience with chemotherapy has mainly underlined the aptitude of nematode parasites to adapt to selective process. It is now considered that any of the novel approaches might at some stage induce selection for resistant populations. The main lesson to be drawn from the drug resistance process is the fact that the only way to achieve a sustainable control of disease should be based on an integrated approach combining complementary solutions responding to the 3 principles briefly described hereby.

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Breeding and farm animal welfare

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Introduction Recent concern about farm animal welfare has centred on the impact of intensive environments and management practices on the animal. For instance, there has been much concern over the use of close confinement systems (e.g. battery cages or sow stalls) and the perceived negative outcomes of these, including development of abnormal behaviour, stress and resulting physical disease or poor health. However, this emphasis on the physical environment is changing, with greater consideration now being given to animal factors and in particular the selective breeding of farm animals. This is partly because of the growing understanding that genetic selection narrowly focused on production traits may be as significant a factor affecting welfare as the systems in which we manage our farm animals (see Lawrence et al (2004) for a more comprehensive review). However, it is important to note that reduced welfare is not a necessary consequence of selective breeding, and indeed animal breeding may have potential to enhance welfare (e.g. Jones and Hocking, 1999). In this paper we use examples from our own research on dairy cattle, sheep and pigs to illustrate positive and practical contributions that selective breeding can make to reducing welfare problems by creating more balanced breeding programmes or providing tools to address welfare problems.

Broader breeding goals Research from a growing number of countries, including the UK, has provided evidence of unfavourable correlations between milk production and health traits in dairy cattle. By accounting for these genetic antagonisms in selection programmes, it is possible to breed productive animals that are expected to be physically healthier. Recent research in SAC and the University of Edinburgh has been expanding the current £PLI index (which has milk, fat and protein yields and lifespan in the goal) by adding indicator traits for resistance to mastitis (somatic cell count) and lameness (locomotion score). Selection on the revised index is expected to benefit cow welfare, compared to selection on earlier versions, by slowing the expected unfavourable correlated responses in mastitis incidence (0.32 cases to 0.21 cases per cow). The additional benefit of selection on the expanded £PLI index in all parts of the breeding sector is predicted to be worth an extra 5.5% in economic returns per cow per year relative to selection on production only (Coffey at al, this conference). This benefit is expected to rise further when fertility is included in £PLI later this year. We are continuing this approach by investigating additional indicators of 'robustness' in dairy cattle, including genetic variation in energy balance, in a range of production environments. We will also investigate whether selection on such indicators is likely to have any unforeseen adverse ethical or welfare consequences.

We have followed a similar approach to the development of broader breeding goals in hill sheep, with the emphasis on reducing mortality, in research at SAC and the Roslin Institute. In addition to being a production loss, lamb mortality is also a source of considerable suffering in the form of starvation and hypothermia. To tackle this we have developed indexes which include ewe longevity and lamb survival in the selection objective alongside more conventional traits, such as lamb carcass production (Conington *et al*, 2001). Importantly these indices take account of both the costs of higher lamb mortality and of ewes carrying a higher lamb burden. The indexes are expected to lead both to improved ewe and lamb survival and improved overall economic returns. Other work in SAC (Dwyer et al) is investigating improved (behavioural and other) indicators which may assist selection for reduced lamb mortality.

In pigs we have recently developed tests which are potentially useful in selection programmes to reduce aggression (Turner at al), though again, the ethical and welfare consequences need to be examined. As part of a collaborative research project led by the University of Newcastle, we are also investigating direct and maternal genetic influences on piglet mortality, in the hope of producing breeding tools to reduce this significant welfare problem.

Where next? In principle animal breeding combined with economics research can make a more general contribution to resolving animal welfare issues, by providing a framework for the quantitative evaluation of the costs and benefits of an animal production system. The advantage of the approaches currently used in multi-trait selection is that they transform all traits (production or welfare based) to a common currency allowing direct comparisons of costs and benefits. Currently the weights applied to traits reflect their expected economic value to the producer. This approach is likely to underestimate animal-based non-economic (moral) aspects such as the pain or discomfort associated with lameness, and new approaches are needed to more fully account for these moral values. Approaches such as contingent valuation, which has been widely used in economics to derive values for non-economic activities, may help to address this problem. The question of who should pay for the addition of these moral values to a breeding index remains open.

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Breeding meat-type chickens for changing demands

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There are many changing demands from consumers, retailers and producers affecting selection decisions in meat-type chickens. The most important changes in demand, especially in Europe, have been to improve (1) food safety (2) poultry health and welfare and (3) the environmental impact of chicken production.

The contribution of the breeding company to improved food safety has been to exclude human and/or chicken pathogens from the stock delivered. This has been achieved by pathogen eradication and substantial investments in biosecurity. For instance, it is now expected that breeding stock will be delivered free of all Salmonella species. Actions to eradicate all Salmonella species from elite breeding stock have succeeded. We have made substantial investment in biosecurity and surveillance so that the risk of challenge is reduced and any new challenge is quickly detected and eradicated.

The quality of chicken meat can also be affected by pathogens that are not vertically transmitted. Breeders can influence the incidence of these through selection for general health and immune function.

This paper presents data from our populations under selection, internal trials and from production populations in a number of countries to demonstrate that we are able significantly to improve the robustness of our chickens. This means that they grow in a wide range of environments with improving standards of health and welfare. The robustness traits under selection include skeletal quality and improved heart and lung function. Despite an increase in disease challenge and a decline in broiler nutrition standards in some countries, there has been a continuing improvement in performance. Robustness has increased as measured by improved skeletal quality, livability and carcass quality and reduced incidence ofascites.

We continue to deliver improvements in growth and feed conversion ratio. These improvements continue to benefit the environment through more efficient resource utilization and reduced environmental pollution.

Breeding and animal welfare: threats and opportunities

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Introduction. The art of animal breeding has rapidly advanced into an exacting science including such advanced tools as Best Linear Unbiased Prediction (BLUP) and REML estimation of variance components. Unfortunately in most selection programs impacts of animal behavior are not considered, as a result those breeding programs ignore traits that may negatively impact animal welfare. The threats of ignoring animal welfare in breeding programs are three fold: first, if higher producing animals tend to be more competitive, then the effect of selection is to increase competition, which worsens animal's welfare; second, increased competition has the effect of lowering productivity of other animals that are in direct contention, thus resulting in reduced (or negative) gains for productivity; third, genotype-genotype interactions (competition) invalidates the traditional BLUP animal model and negates many advantages of this technology and could in fact make it a liability. These threats can be addressed through alternative breeding programs.

Opportunities to addressing animal well-being through genetics. From a geneticists perspective, all quantitative traits are the result of the combination of genetic and environmental sources of variation. Environmental in this case is all inclusive meaning management, housing, temperature, feed, etc., i.e. any resources or limitation imposed by the environment surrounding the animal. Thus, the solutions to animal well-being are to either change the environment such that competitive interactions are minimized or to change the nature of the animal such that their natural instincts to establish social dominance and territory is reduced or eliminated, i.e. either change the nature or the nurture of the animal (Kjaer and Mench, 2003). Changing an animal's nature to address animal well-being concerns is unacceptable by some because of ethical or moral objections. However, we should recognize that all animals used for draft, food, or fiber have been extensively altered by man over the past several millennia from their wild ancestors to those we utilize on today's farms, this is the process called *domestication*. These changes were the direct result of the evolution of man from a nomadic hunter gatherer to a member in a civilized agrarian society. Through breeding we need to further the domestication process initiated by early man, but different tools and objectives are needed because the problems associated with modern confinement operations are also different.

Alternative Genetic Opportunities to Improve Animal Well-being There are many opportunities to address animal well-being in breeding programs, these include direct and indirect methods. Direct methods include: 1) directly measure agonistic behavior on each animal and include such information as an objective to select against (Faure et al, 2003), and 2) genomic methods whereby genes associated with undesirable behaviors are identified and animals are screened for adverse alleles using molecular genetic tools (Muir, 2003a). Indirect methods do not measure undesirable behaviors but rather make the results of undesirable behaviors (competitive or misdirected feeding behaviors) part of the selection program (Muir, 2003b). That is, undesirable behaviors such as fighting, biting, clawing, or pecking, regardless of the intent of the act (aggressive, escape, or misdirected feeding behavior) can produce anything from mild stress to injury or death. All stress, injury, and especially death negatively impact several other traits, including those of economic importance. Thus an indirect way of improving animal well being is to change the animal such that production of the group, in a social setting, is optimized. Methods to accomplish this goal include 1) group selection (Muir 2003b) and 2) advanced mixed models with a second random effect for indirect genetic effects (competition) (Muir and Schinckel, 2002). Both methods have been verified in poultry breeding applications and have resulted in dramatic improvements in livability, productivity, and welfare. The power of group selection was demonstrated in a poultry layer breeding program. Livability in colony cages, under condition of intact beaks and full lighting, improved over 800% such that mortality in the group setting was not different from that of birds housed in single bird cages, while egg production, both per hen house and per hen day improved. Use of mixed models with a second random effect (CBLUP) to address competition was demonstrated using Japanese quail, selecting for 6 week weight in group cages of unrelated birds. A parallel selected line, using standard animal model BLUP (SBLUP) was also developed as a positive control. After 22 selection cycles, standard selection with SBLUP resulted in 400% increase in mortality and no improvement in 6 week weight while ABLUP resulted in 32% decline in mortality and 12% increase in 6 week weight.

Conclusion: Animal well-being can be addressed by commercial breeders without measuring additional traits or increasing the cost of the program by changing to group selection or use advanced mixed models incorporating competitive effects. The only additional information needed is to record pen number.

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New advances in controlling poultry disease

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In today's global climate of consumer preferences or legislation for reduced antibiotic use in animal production, genetic approaches to health provide a natural and sustainable method to help ensure the wholesomeness of the food supply. The tools of molecular genetics have recently enabled the search for molecular genetic markers for health (Lamont, 1994, 1998). Although there are a few notable examples of health traits controlled by single genes, the vast majority of health traits are controlled by multiple genes.

Genomic scans with polymorphic markers, such as microsatellites, can be used to locate the many genomic regions that harbour loci controlling immunity and resistance. Although linked markers can be used for some generations to select for beneficial traits in the breeding population, if the genetic marker is not the causal variation, then the linkage with the desired trait will break down over time. However, the genome scan can be very useful in helping to identify positional candidate genes. By comparing the currently gene-poor map of the chicken with the highly informative genome maps of mouse of human, likely candidate genes that are located in regions of conserved synteny with the marker can be identified. They then need to be tested for effects on the health traits of interest. This is a positional candidate gene strategy. Candidate genes can also be identified by thoughtful and thorough review of existing information on the mechanisms of the health trait of interest and any reported genetic associations. Those genes, even if not yet identified or mapped in poultry, can then become biological candidate genes for investigation.

The strategies of genomic scanning and candidate gene investigations have been successfully applied to poultry immune response and disease resistance in several laboratories, including my own. We have used these approaches to identify specific genes and genomic regions associated with bacterial burden after challenge with pathogenic Salmonella and with response to commercial Salmonella vaccines (Kaiser and Lamont, 2002; Kramer et al., 2003; Lamont et al, 2002) and with antibody response kinetics in the adult hen (Zhou and Lamont, 2003; Zhou et al., 2003). Each of these traits appears to be controlled by multiple genes, each of which contributes a small portion to the overall phenotypic variation in the trait.

In addition to detectable variation in DNA structure, the effect of variation in gene expression can reveal valuable information for genetic enhancement of animal health. The level of expression of genes, and not structural variation, may be the most important for some health traits. Especially useful research approaches at the current time are quantitative real-time PCR to estimate relative amounts of message of specific genes, such as cytokines, and the massive parallel assessment of gene expression through microarrays that can contain tens of thousands of gene fragments. Both strategies identify genes that are up- or down-regulated under different treatments, such as specific conditions or certain groups of animals.

The use of pure, recombinant proteins to enhance health in poultry is an emerging area that has resulted from research on the molecular genetics of the poultry immune response. The identification of genes encoding important communication molecules of the immune system, such as cytokines, has provided the means to produce large and pure quantities the natural proteins that the chicken uses to protect itself. These proteins can act as enhancers for immune function, including vaccine response.

There are multiple good strategies that have been, and can be, used to generate the fundamental information needed to integrate health genetics into a breeding program. Which strategies are the best at any specific time, is dependent upon many factors, including the size and structure of the breeding company, contemporary field problems with infectious disease, consumer-preferred or legislated use of specific antibiotics and management options, and the state of scientific knowledge and technology in genetics and health. Genetic selection for improved immunity and resistance traits can improve the welfare and production efficiency of flocks, as well as reducing the potential for the introduction of food-borne pathogens into the food chain for human consumption.

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Management factors and the control of *Campylobacter* spp. in broilers

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Campylobacter spp. are commonly isolated from commercial poultry flocks. Data from recent FSA-funded UK research indicate that approximately 60% of
housed (broiler) poultry flocks are campylobacter-positive at slaughter age. This will vary from company to company and from farmer to farmer. Data suggest that this may be non-random variation, with consistent patterns observed. Evidence from companies, who collaborate with the Bristol Food Safety Group, is increasingly suggesting that some farmers find it easier to protect their birds from colonisation with *Campylobacter* spp than others. There are a number of possible reasons for this, which may also be interrelated.

A pilot survey of management practices undertaken by Bristol Food Safety staff found that the risks of housed broiler flocks becoming colonised with *Campylobacter* spp. were reduced by farmers using dedicated footwear for each broiler house, frequent incineration of dead birds and where chlorine was added to drinking water. Conversely rates were higher where other domestic animals were present, dead birds were stored on farm for subsequent disposal and where farm hygiene was poor. It is important that the lessons/measures learned from the successful farmers are transferred to those who find control more difficult. A number of UK poultry companies are examining whether biosecurity measures shown to be successful in parts of Scandinavia will work in the long term in the UK. Control may be difficult to sustain and other measures may be needed. Feed treatments to manipulate the gut flora and/or the use of probiotic bacteria may aid control. *Campylobacter*-negative broiler flocks have been shown to contain a lactic acid bacterium, which kills *Campylobacter* in vitro. Work is needed to establish whether this naturally occurring potential probiotic can be used as part of a control package. Work at Bristol is also suggesting that there may be a link between flock health and performance and *Campylobacter* status. This is currently being investigated.

Animal genetic resources management and poverty

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Introduction

An estimated 1.96 billion people rely on livestock to supply part or their entire daily needs. Socio-political, economic and agroecological determinants are leading to dramatic genetic erosion in animal genetic resources (AnGR) important to the livelihoods of many of the world's poor (Anderson, 2003). The poor need AnGR suitable for their purposes. Genotype-environment interactions mean that animals bred for intensive production systems are often not appropriate for the production systems the poor utilise (Anderson, forthcoming). In addition, there is significant option value for society of the AnGR kept by the poor (Drucker *et al*, 2001). There are important genetic and socio-economic reasons why AnGR should be conserved '*in-situ'*. Adaptive traits are best maintained through processes of natural selection brought about by exposing AnGR to changes in local environments. A greater set of benefits should accrue to those directly involved in the conservation activities.

Problem statement

To establish sustainable AnGR management regimes capable of making contributions to improving the livelihoods of poor livestock keepers greater understanding is required of:

a) The ways local communities organise ownership, access and management of AnGR;
b) The enabling environment required for local people to best maintain and enhance AnGR.

Once a) & b) are better understood sustainable AnGR management regimes should provide the means whereby local, national and international property rights systems are integrated to provide security of assets for the poor and processes of benefit sharing from the maintenance and realisation of the option values of AnGR managed by the poor.

Local AnGR property rights systems

AnGR are subject to different rights & mores from which the idea of property can be disaggregated in different ways. Firstly, the selection of the animal, which may involve purchase, loan, exchange etc., at the moment of breeding. Secondly, the right to make and implement husbandy decisions central to the rearing of the animal. Thirdly, the right to prescribe slaughter (often reserved to God only - the duty/ responsibility for avoiding and preventing any harm to the animal it is left to the human owner). These rights of access and use are regulated by gender, status and scope rules (Centonze & Anderson, forthcoming).

Local AnGR property rights systems often distinguish between productive and reproductive (genetic) resources. The Raika pastoralists in Rajasthan have a single term independent of species for animals for reproductive purposes - "Saand". Saand (sheep, goats, cattle, buffalo) have religious value and are often protected by rules preventing sale[1] or being slaughtered, in order to maintain the 'value' of the productive unit. The productive unit can be a single household, in case of sheep and goats, or the whole village in case of cattle and buffalo. Similar cultural value is assigned to Chiapas sheep by Tzotzil indigenous shepherdesses and this impacts upon ownership duties and property rights and precludes the use of the animals as food.

The way AnGR is managed in low external input systems is also dependent upon the property rights of the livestock owners over the resources required in the rearing process. In many such systems one of the functions of animals is to convert common property resources into private property. Animals grazing and consuming water on common land not only grow and produce but they also transfer nutrients from the grazing area to where they are kept and dung can be collected. Such transfers also involve changes from low to high quality and low to high value resources (Dorward & Anderson, 2003). Local property rights systems often allow these transfers to happen and some recognition of the private benefit achieved is reqired. Disturbance of poor livestock keepers' rights of access to common property resources required for animal production will mean that the sustainability of AnGR management will decline.

AnGR conservation by the poor

Social marginalisation and poverty remove access to resources important to the sustainable management of AnGR. Poor households often take decisions that reduce AnGR based on short-term livelihood priorities, rather than emphasising longer term aspects of AnGR access and improvement strategies. This continues to be the case until incentives are provided or benefits accrue to those involved in activities that conserve AnGR.

Examples exist where investment in social organisation by and within marginalised livestock keeper groups can provide benefits in terms of more sustainable AnGR management & genetic improvement, accompanied by equitable access to the resources and livelihood improvements.

Investment in the human and social capital of Mayan communities in SE Mexico led to the re-valueing of plants (local legume varieties) and AnGR (local pig breed). Whilst the processes that targeted plant and animal genetic resources were both enabled by outsiders, aspects of social organisation favoured the conservation of the local pig breed and a

[1] Saand can be exchanged but not for direct monetary profit. However, the idea of profit is not totally excluded in the dynamic development of local property rights rules.

more non-exclusive sharing of benefits. Firstly, a non-cash transfer system was customary for the payment of mating service whereby the owner of the boar takes one of the resulting litter. Thus, only successful matings were paid for and even sow owners without money could afford to mate their animals. Secondly, pigs and pig products were traded locally following a traditional system of equitable allocation of sale days across households. This meant that competition for sales opportunities between pig keepers was minimised. Thirdly, most pig keepers were women and they demonstrated more willingness to share ideas of improved pig keeping, than the men involved in crop innovations who tended to covert information. Interestingly, in many cases the women and men were from the same households (Anderson *et al*, 2002).

The success of one of the few cases of genuinely participatory AnGR improvement is due, at least in part, to the recognition and respect of local property rights. In Chiapas, Mexico, ethno-veterinarians have enlisted the expertise of Tzotzil shepherdesses in a genetic improvement programme of three local sheep breeds run by a university (Perezgrovas, 2001). The rights of the Tzotzil people over the local sheep breeds have been maintained through:

- the nucleus flock was founded from the local population and is managed in a way comensurate with local customs;
- representatives of the Tzotzil shepherdesses make all the breeding & culling decisions;
- Tzotzil communities get first choice of the progeny of the nucleus flock..

Demonstrable genetic gain has been achieved in the traits prioritised by the local people and a high demand for rams produced by the programme is evident from Tzotzil communities (Perezgrovas *et al*, 2003).

Final remarks

Collective action for the management of AnGR by the poor is only possible where the genetic resource is central to livelihoods in cultural and/ or socio-economic terms. The way such collective action proceed (in terms of equity of access, exclusivity of benefit distribution etc.) depends not only on the characteristics of the local AnGR ownership rights, but also the access to rights over the common property resources required for animal production. Although AnGR conservation is a public good creation activity, private benefits have to accrue to those involved. This is particularly the case where the poor are to involved and protagonists and are recognised as prior owners of the AnGR.

A global perspective on the value of animal genetic resources

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Challenges in animal production Recall the primary purpose of farmers using animal species: to supply product, in response to human demand for a broad range of food and other services. 21 billion animals of some 2400 breeds across 30 animal species account for more than 30 percent of the total value of global food and agriculture (FAO-UNEP. 2000), with demand for animal products projected to double by 2020 (Delgardo *et al.* 1999). The animal attributes of product quantity and compositional quality, together with a number of biosecurity issues, a mix and timing of outputs with available inputs, and the market increasingly impact farmers' returns and challenge their ability to manage risk and sustain production.

Genetic resources and farming systems Recall also that the broad range of local farming systems has been developed over decades to millennia. A fundamental element of the systems is their genetic resources, providing the expression blueprint and continuity over time but still with substantial ability to change. This microbial, plant and animal genetic material was over long time periods sampled repeatedly and crafted by a broad mix of stressors which were associated with the farming system, forming varieties/breeds (FAO-UNEP. 2000). Farmers developed these systems to capitalise on the genetic differences amongst varieties, species and between the plant and animal kingdoms, commonly establishing for their system particular combinations at each of these genetic levels (FAO. 2001). In the short term the genetic resources and their adaptive fitness to the farming system stressors substantially determine the ease with which the system can be sustained.

Better breeding strategies More recently, human demand for food and services increased. The earlier slow rates of genetic change may now have been inadequate. Farmers began to apply the principles of 'like-begets-like' and then of Genetics to structure their animal herds/flocks in ways which markedly increased genetic change in the traits of interest. They have imported and used exotic breeds, further developed local breeds, and used breed substitution, crossbreeding, and recurrent selection. Approximately half the gains in the animal component of those farming systems utilising well-planned selection programs have been genetic. The current rapid developments in measurement, molecular and information technologies will likely increase this again as well as enabling new opportunities for maintaining genetic and ecosystem diversity.

Opportunities The need remains to broaden the sound application of the tried and proven genetic principles. For example, it is estimated that whilst 1853 (0.51) of the 3650 breeds which are widely used by 169 developing countries, only 112 (0.06) of these breeds are undergoing active genetic improvement. In the 82 low-income-food-deficit countries there are just 13 (0.01) breeds involved in active genetic improvement. This compares with an estimated 373 (0.67) active breeding programs amongst 558 breeds used widely in 27 developed countries. Further, the world's developing sector has by far the majority of animals and breeds, with much larger dependency on animals. There have been many attempts to establish active genetic improvement programmes in these developing countries. The reasons for partial or major failure of the interventions over the past half-century in many countries can be summarised as: 1) Inadequate involvement of the range of stakeholders when planning and implementing genetic improvement activity; 2) Poorly established local development directions for livestock; 3) Lack of documented and agreed operational plans; 4) Inappropriate mix of technologies, including unsuitable genetic resources, ineffective use of local and high technologies, inappropriate genetic improvement program designs; 5) Unsuitable investment strategies; 6) Inadequate institutional capacity at one or more levels; 7) Inadequate human resource capacity at the various levels of decision-making and action involved; and 8) Natural disasters and wars and civil unrest.

Public policy and genetic improvement Animal genetic improvement can possess a strong element of public good. In addition, the very nature of animal genetic resources means that many of the decisions impacting 'farm-to-plate' production of food and services from animals will, overtly or covertly, have implications for the quantitative genetic variation involved. Many areas of public sector policy may impact the type and effectiveness of strategy used to generate and disseminate genetic improvement. Both enabling and disabling effects are possible so care is required with policy design. Some example broad policy areas with the potential to seriously impact genetic improvement are: land use and water, animal production and product processing and marketing standards, energy, human nutrition, input/product pricing, environmental management, research and development, biosecurity, information networking, credit instruments. The recent development of traceback systems will provide added potential to strengthen and broaden breeding programmes, and food labelling will facilitate development of genetic diversity and clarify price signals to the farmer, leading to better defined development objectives and breeding goals.

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Economic values for diversity

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Livestock genetic diversity has both a public and private value, yet little work has been done to measure this concept in economic terms. The presentation outlines the main challenges facing applied and theoretical economists in the study of genetic diversity in livestock production systems. It surveys basic economic principles such as the marginal value of an increase in genetic diversity, and its cost of conservation in the market environment. Market-driven devices for increasing consumer's awareness of, and willingness-to-pay for livestock diversity are investigated.

The potential role of regulation, farmers' incentive through agricultural policy and the global market are examined in turn to set the scenario for future production in the light of recent changes in the common agricultural policy.

Needs and priorities for rare breed conservation in the UK

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With the publication of the UK Country Report to the FAO on Farm Animal Genetic Resources in 2002, UK Government recognised that national Farm Animal Genetic Resources (FAnGR) includes two main groups – Mainstream Breeds and Breeds at Risk. Within Breeds at Risk, two distinct components have emerged: a) those breeds that are locally adapted and/or distinctive but not numerically scarce, and b) those which are rare and therefore in need of more urgent conservation action. In the UK, the Rare Breeds Survival Trust (RBST) administers native rare breed conservation in association with the relevant breed societies and individual owners. The RBST is a registered charity and membership organisation, established in 1973 as an extension of a working party formed in 1968 by the Royal Agricultural Society of England and the Zoological Society of London to save endangered breeds of UK livestock. Previously, no formal support or recognition structure existed for native breeds of farm animal in danger of extinction, and at least 20 native breeds had vanished during the 20th century as a result. In the last thirty years the work of the RBST has successfully ensured that no further extinctions have occurred, but now some real opportunities for expansion of its traditional conservation activities exist. Through publication of the Country Report, the UK now formally recognises 24 rare cattle breeds, 2 rare goat breeds, 8 rare pig breeds, 36 rare sheep breeds, 17 rare equine breeds and 9 rare poultry breeds, and with a number of national strategies emerging to coincide with EU agricultural reform, an opportunity exists to reassess needs and priorities in several main areas for this valuable component of UK FAnGR.

Conservation

Rare breed conservation has undergone certain changes in recent years, as the need to maintain genetic diversity in those breeds that have survived has gradually emerged as a major key to their continued success and survival in addition to maintenance of population size. Although basic population and demographic data has been recorded for rare breeds and most have kept detailed pedigrees, there is still incomplete information available in relation to current population genetic structure and dynamics over time. It is only through familiarisation with historical patterns and current population genetic structure that future strategy can be well informed, and this information is vital for owners and rare breed organisations if effective conservation programmes are to be designed which can keep abreast of new challenges to long-term survival. Currently, the scope of rare breed conservation programmes managed by the RBST is increasing, both as a result of improved information retrieval and analysis, but also as the result of resources made available through a RBST national appeal to raise £2.5 million in the wake of the recent FMD outbreak in the UK.

Characterisation

Most rare breeds, in addition to being numerically scarce, are also locally adapted and/or distinctive, which means that there is considerable scope for development of markets for specialist produce or behaviour. This development will be difficult, however, without proper characterisation of the specialist traits in question. Much of current evidence suggesting that rare breeds are uniquely able to meet specialist market demand is anecdotal. This view has been substantiated within a number of recent reviews of the role and development of UK rare breed FAnGR, which have all identified that limited comparative and/or experimental data is available. Finding new roles for rare breeds is at the heart of ensuring their successful future, but unless they can be strategically marketed based upon reliable characterisation, new markets are likely to be under explored.

Infrastructure

Provision of dedicated resources and co-ordinated national development of efficient communication networks among Government, NGOs, extension services and research institutes is increasingly important as initiatives and research expand in relation to UK FAnGR. If this infrastructure is improved, efforts should be taken to ensure that it does not become too top heavy, and that effective means of communicating progress and new opportunities for involvement among relevant Breed Societies and individual owners are also developed. No matter how well conceived, significant participation of rare breed owners in new regional or national initiatives is unlikely without timely provision and uptake of associated information and management structures at the grassroots level.

What do genetic resources mean to flora?

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As a plant scientist and curator of plant genetic resources (PGR), my mission is the conservation, management, characterisation and promotion and subsequent utilisation of these resources. The public ex-situ collections under my charge are seed collections of arable crops and their wild relatives. These include the BBSRC Small Grain Cereal Collections and the JI Pisum Collection (GRU). Seeds are stored under medium term storage conditions of 1.5^0C and 10%RH. The collections are based at a research institute where they benefit from being integrated into a range of applied and fundamental projects. My job combines curation and active research associated with the collections and entails extensive collaborations across a range of stakeholder groups which include, commercial breeders, farmers and growers, museum curators, archeologists, schools to exhibition and agricultural show organisers. Clearly no collection works alone. PGR collections in the UK are decentralised around different institutions, each of which is involved in European PGR networks through which regional initiatives and responsibilities to international agreements are coordinated.

Conservation

High quality seed is expected to maintain good viability under our conditions for up to 30 years. This reduces the need to regenerate the material at short intervals and thus increases the number of accessions, which can be maintained by a small number of staff. While in storage, seeds are safe from biotic and abiotic stresses and with the exception of ageing and associated chromosomal damage, this is the best place for the seed to be.

Management

As active working collections, the material is grown out for regeneration, multiplication and research, both under glass and in the field. As one might expect, there is a high degree of seasonality associated with such material and work is organised around both spring and autumn programmes. Management of large collections invariably means a high degree of record keeping and I am responsible for developing and managing computer systems to hold data relating to seed stocks, passport and characterisation data. These are essential tools in their own right and enable complex queries to be asked of the holdings when trying to extract specific subsets of accessions and information to help answer enquiries. Plant genetic resources calls for dynamic management. While the basic housekeeping of collections may be routine, flexibility is required to ensure that they remain well integrated and are of high strategic relevance to the changing priorities of commercial plant breeding and the changing ways in which biological research are being conducted today.

Characterisation

During the spring and summer, the major activity focuses on using the active growing season for recording details relating to plant morphology and performance, while also making comparisons with past notes. There is a strong emphasis on the genetics underlying morphological variation and this is a key time to look for novel variation. This can either be material that has not been scored previously or spontaneous mutants or variants that arise during the course of growing. The *Pisum* collection contains reference stocks of such mutants associated with the *Pisum* gene list (PGene). There is no substitute for time spent with the material itself. However good ones observational skills, they need to be kept in constant practice. Active engagement in genetic analysis of variation and germplasm enhancement has been helpful in broadening the understanding of the stocks and realising greater utilisation of the resources.

Advances in molecular biology, have resulted in a dramatic increase in the amount of molecular characterisation of PGR. Entire collections are now being screened for novel alleles of isolated genes of economic importance. This has lead to the formation of DNA banks as additional resources to the material itself. I predict that within 10 years, all major PGR collections will have been characterised in this way. These new technologies are providing new insights into PRG by helping us to understand issues such as domestication of crops and are of direct use in structuring management of collections and in identifying priority material and areas for further study, collecting or complimentary in-situ conservation.

Promotion and utilisation

The promotion of resources is a continuous activity. Unless people are aware of what is available they will never be used. Clearly there is a whole range of ways in which this is done, from web pages, talks, demonstrations, papers in scientific journals to articles in the press and trade magazines. The Pisum collection has a high public profile due to the pioneering work of Gregor Mendel in the 1860s (Mendel Museum), and the collection is involved in providing historical context for the study of genetics and the newer developments in genome sequencing, gene therapy and genetic engineering.

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