

ANIMAL NUTRITION

Comparison of barley and barley/maize based finishing diets for young bulls

Maize meal is included in cattle finishing rations with a view to improving performance and increasing the rate of fattening to achieve earlier finish. Young, rapidly growing dairy bulls that have high protein and low fat deposition rates are a suitable model to evaluate this. Maize meal is higher in energy and oil, and lower in protein and ash, than barley. The objective of this experiment was to examine the effects of replacing a proportion of the barley in a barley-based concentrate ration with maize meal plus sufficient soya bean meal to ensure an adequate protein content in the diet.

Twenty-four mixed dairy breed young bulls were blocked on weight and breed and assigned to either a barley or a barley/maize meal based ration offered *ad libitum* for a 170-day finishing period. The animals were accommodated in 4 pens in a slatted shed giving 2 replicates per treatment for feed intake measurement. Prior to this they had been on a diet of grass silage + 2 kg/day concentrates. The rations were commercially formulated to specification. After a 3-week adjustment period, the concentrate rations were continuously available and the animals were also offered 1 kg silage dry matter (DM) per head daily to aid rumen function. Feed intake was recorded 3 times weekly and refusals were discarded once weekly. At the end of the feeding period the animals were slaughtered in a commercial abattoir. The data were analysed using general linear model procedures (SAS, 1989/92). The formulation of the barley-based ration was (g/kg): rolled barley 870, soya bean meal 67.5, molasses 47.5 and minerals/vitamins 15. The corresponding values for the barley/maize ration were: 430, 110, 45 and 15. The maize meal inclusion rate was 400 g/kg. The declared analysis for the barley-based ration was (g/kg): crude protein 125, oil 20 and ash 40. The corresponding values measured by chemical analysis were 129, 13 and 54. The barley/maize based ration was declared to have (g/kg): crude protein 135, oil 27 and ash 44, while the corresponding measured values were 143, 22 and 49.

Concentrate intake was higher ($P < 0.05$) for the ration with maize but when scaled for mean live weight, intake did not differ between the two rations (Table 47). The higher intake occurred in the early weeks of finishing when live weight gain was also higher ($P < 0.001$). Thereafter however, the animals on the barley based ration tended to gain faster with the result that for the total finishing period there was no significant difference between the rations in overall growth rate. Neither were there any significant effects on slaughter weight, kill-out proportion or carcass traits. In summary, feed intake was about 3% higher for the maize ration and live weight gain was also about 3% higher. Overall daily live weight gains were very high because the animals were exhibiting compensatory growth following a modest rate of growth earlier.

Replacing a proportion of the barley in a barley-based high concentrate ration with maize and soya bean meal increased ration crude protein and oil concentrations. It also increased intake in the early weeks of finishing and there was a corresponding increase in live weight gain at this time. However, it had no effect on overall intake or live weight gain and there were no effects on slaughter or carcass traits.

Table 47: Performance and slaughter traits of young bulls offered barley or barley/maize-based finishing rations

	Barley	Barley/Maize	s.e.	Significance
Intake (kg/day DM)	9.21	9.54	0.10	*
Intake (g/kg LW)	23.3	23.9	0.26	NS
Live weight gain (g/day)				
0 to 40 days	1025 ^a	1458 ^b	79.9	***
41 to 170 days	1908	1831	65.2	NS
0 to 170 days	1697	1745	58.4	NS
Slaughter weight (kg)	540	548	11.4	NS
Carcass weight (kg)	275	279	8.4	NS
Conformation (scale 1 – 5)	2.01	2.01	0.113	NS
Fatness (scale 1 – 5)	2.98	3.09	0.136	NS
Kidney and channel fat (g/kg)	27.9	29.1	2.23	NS

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Feed intake pattern, behaviour, rumen characteristics and blood metabolites of finishing beef steers offered total mixed rations constituted at feeding or ensiling

In a previous part of this study, offering varying silage: concentrate ratio total mixed rations (TMR) constituted at ensiling resulted in lower intakes and poorer performance and carcass traits than when similar TMRs constituted at feeding were offered. It was hypothesised that the lower intakes of the TMRs constituted at ensiling may have been due to their greater bulk as a result of effluent absorption by the concentrate component and that this resulted in a slower clearance from the rumen and passage through the gastrointestinal tract. Therefore, the aim of this study was to investigate the effects on intake pattern, behaviour, rumen characteristics and blood metabolites in steers of (1) different ratios of grass silage and concentrates, (2) method of feed preparation (TMR constituted at feeding or at ensiling), and (3) to ascertain if there were interactions between concentrate proportion in the TMR and method of feeding.

The experimental silages were prepared from the first cut of a perennial ryegrass (*Lolium perenne*) sward, precision chop harvested on 7 – 9 June 2005, and ensiled without an additive. In three treatments, namely EL, EM and EH, a coarse concentrate ration was mixed with the herbage at ensiling (CEM) in approximate dry matter (DM) grass: concentrate ratios of 75:25, 50:50 and 25:75, respectively. A fourth treatment consisted of herbage ensiled alone (SO). The DM content of the grass was estimated regularly throughout the harvesting period by microwave drying a sub-sample until a constant weight was achieved. These DM values were used to calculate the weight of grass DM in the loads to which the concentrate was to be added. The appropriate quantity of concentrates was then mixed with the grass on a concrete yard and the mix was placed into the silo, spreading well to ensure thorough mixing of grass and concentrates. After filling the silos, the feedstuff was compacted, sealed with two sheets of black polythene (0.125 mm thickness; IS 246 1989) and weighted with tyres and silt. The concentrate ration ensiled with the herbage consisted of 847 kg rolled barley, 102 kg soyabean meal and 51 kg molasses per tonne. The mineral and vitamin pre-mix was omitted to avoid the risk of stimulating a clostridial fermentation.

The animals used were 112 late maturing (80 Charolais and 32 Limousin) crossbred steers. Prior to the experiment, these animals were housed in a slatted floor shed and offered grass silage *ad libitum* to standardise gastro-intestinal contents. Based on the mean of two

consecutive daily liveweights recorded at the start of the experiment, animals were blocked on weight, within breed type, and from within block were randomly allocated to 16 replicate groups. Two replicates were assigned to each of the following treatments (n=14), (percentage inclusions are on a DM basis):

1. Silage only (SO)
2. Silage (75 %) plus concentrates (25 %), offered as a total mixed ration (TMR) constituted at feeding (FL)
3. Silage (50 %) plus concentrates (50 %), offered as a TMR constituted at feeding (FM)
4. Silage (25 %) plus concentrates (75 %), offered as a TMR constituted at feeding (FH)
5. Silage (75 %) plus concentrates (25 %), offered as a TMR constituted at ensiling (EL)
6. Silage (50 %) plus concentrates (50 %), offered as a TMR constituted at ensiling (EM)
7. Silage (25 %) plus concentrates (75 %), offered as a TMR constituted at ensiling (EH)
8. Concentrates plus 1 kg silage DM/head/day (AL)

The AL treatment was included to allow a complete assessment of the animal response to concentrate input from zero to *ad libitum* concentrates. Following allocation to treatment, all animals were treated with the anti-parasitic remedy Qualimec (Janssen Animal Health; 1 % ivermectin, 1 % benzyl alcohol) and were vaccinated against Infectious Bovine Rhinotracheitis (IBR) and parainfluenza (PI3) using Bovilis (Intervet UK, Ltd.). They were also treated with Butox pour-on (Intervet Productions S.A.; deltamethrin 0.75 % w/v) to control skin lice. They were subsequently housed in a slatted floor shed fitted with Calan-Broadbent electronic feeding doors (American Calan Inc., Northwood, NH, USA) to allow recording of individual feed intake.

Silage was removed from each silo once daily using a shear grab. The FL, FM and FH diets (FED; mixed at feeding), were constituted using SO and the same concentrate ration as that used in the CEM diets but with the addition of a mineral and vitamin premix. Each FED diet was mixed daily for three minutes in an Abbey feeder wagon (Abbey Farm Machinery, Nenagh, Co. Tipperary) and individual allowances were weighed in to each animal. Animals on the FM, EM, FH, EH and AL treatments were adjusted gradually to their diets. All diets were offered at 1.1 times the previous day's consumption, intakes were recorded daily and refusals were discarded twice weekly. Animals had access to fresh water at all times. Animals on SO, EL, EM, and EH received 40, 40, 80 and 120 g/head/day of an appropriate mineral and vitamin premix dusted on the silage.

Feed intake patterns were recorded over a 24 h period on 56 animals on Day 86 (blocks 1-7) and on the remainder on Day 105 (blocks 8-15). Feed boxes were weighed every 20 min for the first 2 h post-feeding, then every hour for the next 2 h and every 2 h thereafter to 12 h with a final weight at 24 h. Animal behaviour, designated as either eating, ruminating or idling, was visually recorded every 15 min for 24 h for 56 animals on Day 107 (blocks 1-7) and for the remaining 56 animals on Day 157 (blocks 8-15). Occasions where animals were observed drinking water were omitted from the calculations as they contributed < 0.01 of total observations.

Four Holstein-Friesian steers of initial liveweight 630 (s.d. 23.2) kg each fitted with a 10 cm internal diameter rumen cannulae (Bar Diamond, Inc., Parma, ID) were used to determine rumen characteristics for four of the experimental diets, namely FL, EL, FH and EH in a 2 (concentrate proportions) x 2 (feeding methods) factorial arrangement of treatments. The experiment was a balanced 4 x 4 Latin Square design with four experimental periods of 26 days duration each. Following 20 days adaptation to the treatments, all measurements were undertaken during days 21 to 26. Animals were accommodated in individual stalls and had access to water at all times. Feed was offered *ad libitum* during the adaptation phase and at 0.95 of *ad libitum* intake during the measurement phase. Fresh feed was offered once daily at 0830. Animals on EL and EH received 40 and 120 g/head/day, respectively, of a mineral and vitamin premix dusted on the silage. Feed was sampled daily at feeding from days 21 to 26.

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Samples were stored at – 18 °C until the end of the experiment and were then pooled to give one composite sample per period for subsequent analysis.

On days 21 and 22 of each experimental period, rumen fluid samples (approx 200 ml) were collected through the rumen cannulae immediately prior to feeding and at 1, 2, 4, 6, 8, 12, 16 and 24 h post feeding to assess rumen fermentation characteristics. Rumen fluid pH was determined immediately after sampling using an Orion digital pH meter and glass electrode. A 20 ml sub-sample was then acidified with 0.5 ml of 9M sulphuric acid and stored at – 18 °C for subsequent analysis.

The rumen pool sizes of liquid and solids were determined directly by manual removal of the total rumen contents. The liquid and solid fractions were weighed, sampled and contents were then returned to the rumen. Samples were stored at – 18 °C for subsequent analysis. This procedure was conducted on three occasions, on Day 23 (0830), Day 24 (1130) and Day 25 (1530). These three times were chosen to represent the pre-feeding, completion of the main meal and full rumen conditions, respectively. On Day 26, two evacuations were conducted at 1030 and 1930 to estimate fractional clearance rate (Kcl). The animals did not receive any feed between the two evacuations, but water was freely available. Rumen contents were weighed and samples were taken and stored at – 18 °C for subsequent analysis.

All 112 finishing animals were blood sampled by jugular venipuncture for nutritional metabolite concentrations of glucose, β -hydroxybutyrate (β HB) and urea. To facilitate the work routine, 56 of the animals were blood sampled on Day 100 (blocks 1-7) and the remainder were sampled on Day 155 (blocks 8-15). Samples were obtained from each animal immediately before feeding and at 2, 6, 10 and 24 h after feeding using separate vacutainers containing lithium heparin and sodium fluoride as anticoagulants. All samples were centrifuged at 2000 x g for 15 min at 4 °C within 1 hour of collection. Plasma was harvested, aliquoted and stored at – 20 °C until assayed.

All data were analysed using Statistical Analysis Systems (SAS, 2002-2003). In the behaviour study, animal was the experimental unit, data were analysed using the general linear models procedure (PROC GLM) and are presented as the proportion of time animals were observed eating, ruminating and idling. Blood metabolites and feed intake pattern over 24 h were analysed using a repeated measures design (PROC MIXED). Treatment differences for both the behaviour and blood variables were determined using *a priori* contrasts for the linear, quadratic and cubic effects of silage: concentrate ratio, the effect of feeding method (FED vs. CEM) and its linear and quadratic interactions with silage: concentrate ratio. Feed intake and rumen characteristics were analysed using PROC GLM and a model appropriate for a Latin Square design with terms for animal, period, concentrate proportion, feeding method and concentrate proportion x feeding method interaction. The data are presented as the main effect means with the significance of factors and interactions indicated. Rumen digesta kinetics / clearance rates (Kcl) were calculated using the logarithmic transformation of the exponential equation $R_{1900} = R_{1100} \times e^{-Kcl \times t}$, where R_{1900} is the amount present at the second evacuation (kg), R_{1100} is the amount present at the first evacuation (kg), Kcl is the fractional clearance rate (%/h) and t is the time (h) between the two evacuations.

The composition of the feed used for the feed intake pattern, behaviour and blood metabolite study is presented in Table 48. All silages were well-preserved, as indicated by their low pH values, relatively low concentrations of ammonia N and butyrate and high contribution of lactic acid to total fermentation products (FP).

Results for 24 h feed intake is shown in Table 49. Total DM intake over the 24 h measurement period increased with increasing concentrate proportion and the linear effect was significant ($P < 0.001$). There was an effect of method of feeding on total DM intake with animals on the FED diets having a higher ($P < 0.05$) total DM intake than those on the CEM

diets. No concentrate proportion x method of feeding interaction was evident for total DM intake over the 24 h.

The pattern of DM intake over 24 h is shown in Figure 9. All animals had higher intakes in the first than in any subsequent 20 min period of the first 2 h. Animals on the AL treatment consumed 0.35 of their total 24 h intake in the first 20 min and had higher ($P<0.05$) intakes than all other treatments for the first hour post-feeding. For the subsequent 4 h, animals on the AL treatment consumed relatively little feed, and then increased intake again to 8 h, by which time they had eaten 0.74 of their total daily intake. In contrast, animals on the SO treatment displayed a more even pattern of intake, consuming only 0.12 of their total 24 h intake in the first 20 min. They consumed 0.43 of their intake in 4 h and had consumed 0.67 of their total daily intake by 8 h. Animals on SO consumed very little feed overnight (0.08 of total DM from 12 to 24 h). The intake patterns for FL, FM, FH, EL, EM and EH were intermediate to those of AL and SO with animals on the higher concentrate diets generally having greater intakes in the first hour and greater total intakes than those on the lower concentrate diets. Corresponding FED and CEM diets displayed similar intake patterns. Feed intake was low overnight for all treatments (0.22 of total DM was consumed from 12 to 24 h).

Results for behaviour are also shown in Table 49. The proportion of time animals spent eating and ruminating decreased linearly ($P<0.001$), while the proportion of time spent idling increased linearly ($P<0.001$), with increasing concentrate proportion. Method of feeding had no significant effect on behaviour. The chemical composition of the four diets used in the rumen study is presented in Table 50. All silages were well-preserved as indicated by their low pH values (3.9-4.1), high lactic acid: acetic acid ratio (8.1-9.8:1), low ammonia nitrogen values (38-72 g/kg N) and negligible propionic and butyric acid contents (0.2-0.7 g/kg DM). The FED diets had a higher DM and WSC concentration and a lower DM digestibility and ash content than the corresponding CEM diets. Both FED and CEM diets had a similar total N content. Total FP and ammonia nitrogen were higher for FL than FH and for EL than EH.

Feed intakes (restricted to 0.95 of previous *ad libitum* intake) are presented in Table 51. Animals offered the higher concentrate proportion diet had a greater ($P<0.01$) total DM intake than those on the lower concentrate proportion diet, while animals on FED had a greater ($P<0.05$) total DM intake than those on CEM.

Results for rumen fermentation variables are also shown in Table 51. Animals offered the higher concentrate proportion diet had a lower ($P<0.05$) rumen pH than those offered the lower concentrate proportion diet while method of feeding had no significant effect on rumen pH. Concentrate proportion had an effect on rumen lactic acid and ammonia concentrations with animals offered the higher concentrate proportion diet having a higher ($P<0.001$) lactic acid concentration and a higher ($P<0.05$) ammonia concentration than those offered the lower concentrate proportion diet. Animals on the FED diet had higher ($P<0.05$) total VFA values than those offered the CEM diet while individual molar VFA proportions were unaffected by method of feeding. Animals offered the higher concentrate proportion diet had a lower ($P<0.05$) molar proportion of acetic acid and a higher ($P=0.06$) molar proportion of propionic acid than animals offered the lower concentrate proportion diet. The molar proportion of *n*-valeric acid were higher ($P<0.05$) in animals on the higher concentrate proportion diet than those on the lower concentrate proportion diet while the molar proportion for total valeric acid tended towards significance ($P=0.09$) with animals on the higher concentrate proportion diet having the higher values. The acetate: propionate ratio was lower ($P<0.05$) for animals on the higher concentrate proportion diet than those on the lower concentrate proportion diet.

Rumen pool sizes are presented in Table 52. No effect of concentrate proportion or method of feeding was found for rumen liquid, DM, OM or NDF pool sizes. Neither concentrate proportion nor method of feeding had an effect on the fractional clearance rates of DM or OM

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(Table 52). Fractional clearance rate of NDF was higher ($P<0.05$) for animals offered the higher concentrate proportion diet.

Plasma glucose concentrations increased linearly ($P<0.05$), while urea concentrations increased both linearly ($P<0.001$) and quadratically ($P<0.001$), with increasing concentrate proportion (Table 53). There was a quadratic ($P<0.001$) relationship between β HB levels and concentrate proportion. Method of feeding had a significant effect on both plasma glucose and urea with animals on the FED diets having higher concentrations of both than animals on the CEM diets. Sampling time and treatment \times sampling time interactions were significant for all blood parameters and these interactions for glucose, β HB and urea are presented in Figures 10, 11 and 12, respectively. Highest glucose concentrations were generally observed prior to feeding. Glucose concentrations declined over the first 2 h, then increased over the following 4 h (except for SO), declined again over the next 4 h and then increased to their normal pre-feeding values over the remaining 14 h. At 2, 6 and 10 h post-feeding FM and FH had higher ($P<0.05$) glucose concentrations than EM and EH respectively, while FL and EL had similar glucose concentrations at each sampling time-point.

As method of feeding had no significant effect on β HB concentration, the values for the FED and CEM treatment means were combined for the low, medium and high concentrate proportions (Figure 11). There was no significant difference at any time between AL and SO. Concentrations of β HB increased ($P<0.001$) for all treatments post-feeding and thereafter remained relatively stable until 10 h post-feeding. Subsequently, β HB concentrations for all treatments decreased ($P<0.01$) and returned to their original level after 24 h. Plasma urea concentration was lowest for SO and highest for AL before feeding. Thereafter to 10 h, SO increased and AL decreased before returning to their original pre-feeding values by 24 h. For the other treatments, plasma urea concentration increased over the first two hours and then remained relatively stable to 10 h before returning to their original pre-feeding values by 24 h.

It is concluded that increasing the concentrate proportion in the diet increased total DM intake despite the decreased proportion of time spent eating and ruminating. It also changed the rumen fermentation pattern from a cellulolytic to an amylolytic profile. Feeding varying silage: concentrate ratio TMRs constituted at feeding resulted in greater intakes, higher total VFA concentrations and higher plasma glucose and urea concentrations compared with feeding similar TMRs constituted at ensiling. While the data fail to provide a clear explanation for the lower intakes and hence lower performance on the CEM diets in the earlier study, the most likely reason was a slower clearance rate of DM and its components from the rumen. For DM, OM and NDF, the fractional rumen clearance rates on CEM were proportionately only 0.76, 0.75 and 0.78, respectively, for those for FED.

Table 48: Chemical composition of the feeds offered in the intake pattern, behaviour and blood metabolite study (mean (s.d.); g/kg (except pH) unless otherwise stated)

	Feeds ¹				
	<u>SO</u>	<u>EL</u>	<u>EM</u>	<u>EH</u>	<u>Concentrate</u>
<i>Chemical composition at feed-out</i>					
Dry matter (DM) (g/kg)	234 (5.0)	266 (20.9)	333 (22.5)	436 (26.5)	861 (5.2)
pH	3.9 (0.15)	3.9 (0.08)	4.0 (0.08)	4.1 (0.04)	
<i>in vitro</i> DM digestibility	721 (11.8)	775 (15.2)	796 (9.2)	820 (13.0)	886 (6.1)
<i>Composition of DM (g/kg)</i>					
Starch					464 (14.3)
Ash	80 (5.6)	72 (6.3)	66 (3.2)	61 (4.6)	43 (6.3)
Total N	22 (1.5)	24 (1.9)	25(1.1)	26 (1.2)	25 (0.6)
Neutral detergent fibre	545 (33.5)	431 (34.3)	396 (36.0)	317 (41.8)	184 (11.1)
WSC	16 (8.7)	14 (3.1)	21 (10.3)	28 (10.9)	
Estimated net energy (UFV/kg) ²	0.77	0.86	0.96	1.05	1.12
<i>Fermentation characteristics (g/kg volatile-corrected DM, unless otherwise stated)</i>					
Ethanol	18 (3.8)	23 (9.0)	10 (2.9)	10 (4.9)	
D-Lactate	74 (16.5)	58 (12.7)	43 (12.5)	33 (13.9)	
L-Lactate	85 (19.6)	71 (7.7)	54 (10.7)	46 (8.4)	
Acetic acid	32 (13.6)	15 (3.6)	18 (5.5)	13 (2.9)	
Propionic acid	2.2 (2.00)	0.3 (0.24)	1.0 (0.55)	0.6 (0.28)	
Butyric acid	0.3 (0.80)	0.1 (0.12)	0.3 (0.42)	0.5 (0.42)	
Fermentation products (FP) ³ (g/kg DM)	211 (28.1)	168 (25.8)	127 (25.6)	101 (40.8)	
Ammonia nitrogen (g/kg total N)	94 (24.1)	81 (21.6)	79 (7.0)	55 (17.9)	

¹SO = silage only; EL, EM and EH = TMR constituted at ensiling (CEM) in approximate DM ratios of grass: concentrates of 75:25, 50:50 and 25:75; ²Unit Fourragere Viande; ³FP = lactic acid + VFA's + ethanol

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Table 49: Feed intake and behaviour of animals in the intake pattern and behaviour study

	Treatment ¹									Significance of contrasts ³		
	<u>SO</u>	<u>FL</u>	<u>FM</u>	<u>FH</u>	<u>EL</u>	<u>EM</u>	<u>EH</u>	<u>AL</u>	<u>s.e.m</u> ²	<u>L</u>	<u>Q</u>	<u>M</u>
Total intake (kg DM)	6.25	9.21	9.43	11.18	6.60	7.22	10.11	11.46	0.392	***	NS	*
<i>Behaviour</i> ⁴												
Eating	0.16	0.13	0.09	0.07	0.12	0.11	0.07	0.04	0.024	***	NS	NS
Ruminating	0.41	0.35	0.28	0.23	0.34	0.29	0.22	0.16	0.016	***	NS	NS
Other	0.44	0.53	0.63	0.70	0.54	0.60	0.71	0.80	0.019	***	NS	NS

¹SO = silage only; FL, FM and FH = TMR constituted at feeding (FED) in approximate DM ratios of grass silage: concentrates of 75:25, 50:50 and 25:75; EL, EM and EH = TMR constituted at ensiling (CEM) in the same approximate DM ratios as FED diets; AL = concentrates *ad libitum* with 1kg silage DM; ²For n=14; ³L, Q = linear, quadratic effects of increasing concentrate proportion; M = effect of method of feeding; ⁴Proportion of observations. There were no significant concentrate proportion x feeding method interactions.

Table 50: Chemical composition of the feeds (mean (s.d.); g/kg (except pH) unless otherwise stated) offered in the rumen characteristics study

	Feeds ¹			
	<u>FL</u>	<u>FH</u>	<u>EL</u>	<u>EH</u>
<i>Chemical composition at feed-out</i>				
Dry matter (DM) (g/kg)	279 (5.2)	452 (6.7)	260 (18.4)	432 (20.5)
pH	3.9 (0.05)	4.1 (0.08)	3.9 (0.08)	4.1 (0.04)
<i>in vitro</i> DM digestibility	759 (10.5)	791 (17.3)	770 (12.2)	805 (13.0)
<i>Composition of DM (g/kg)</i>				
Ash	74 (6.2)	68 (4.2)	66 (4.5)	60 (4.1)
Total N	23 (0.5)	24 (0.9)	24 (1.3)	25 (1.2)
Neutral detergent fibre	472 (7.3)	376 (25.2)	424 (24.2)	310 (21.8)
WSC	24 (6.7)	45 (4.1)	16 (2.6)	29 (3.9)
<i>Fermentation characteristics (g/kg volatile-corrected DM, unless otherwise stated)</i>				
Ethanol	11 (2.3)	6 (0.9)	18 (7.6)	8 (2.9)
D-Lactate	54 (7.4)	25 (2.5)	60 (9.1)	39 (10.4)
L-Lactate	60 (8.2)	36 (4.9)	73 (5.2)	49 (11.8)
Acetic acid	14 (2.6)	7 (1.9)	15 (1.6)	9 (2.9)
Propionic acid	0.3 (0.12)	0.4 (0.17)	0.3 (0.28)	0.5 (0.42)
Butyric acid	0.7 (0.42)	0.2 (0.17)	0.1 (0.15)	0.3 (0.12)
Fermentation products (FP) ² (g/kg DM)	140 (26.7)	75 (14.7)	166 (31.2)	106 (21.0)
Ammonia nitrogen (g/kg total N)	72 (10.2)	38 (11.6)	79 (13.2)	43 (9.3)

¹ See footnote to Table 49; ² FP = lactic acid + VFA's + ethanol.

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Table 51: Feed intake and the pH, concentrations of ammonia, lactic acid and total volatile fatty acids (VFAs) and molar proportions of individual VFAs in the rumen fluid

	Concentrate proportion (C)		Method of feeding (M)		s.e.m. ¹	Significance ²	
	Low	High	FED	CEM		C	M
<i>Restricted feed intake (kg dry matter (DM)/d)</i>							
Total DM intake	9.33	13.49	12.56	10.27	0.576	**	*
<i>Rumen fermentation variables</i>							
pH	6.41	6.17	6.32	6.26	0.056	*	NS
Lactic acid (mg/l)	109	163	136	135	4.1	***	NS
Ammonia (mg/l)	103	155	141	117	10.4	*	NS
Total VFA (mmol/l)	107	112	119	100	5.0	NS	*
<i>Molar proportions (mmol/mol VFA)</i>							
Acetic acid	562	482	522	522	16.1	*	NS
Propionic acid	203	246	235	214	13.2	P=0.06	NS
<i>Iso</i> -butyric acid	14	14	14	14	0.5	NS	NS
<i>N</i> -butyric acid	137	157	136	158	10.1	NS	NS
Total butyric acid	151	171	150	172	9.9	NS	NS
<i>Iso</i> -valeric acid	54	52	52	54	4.0	NS	NS
<i>N</i> -valeric acid	30	51	42	39	5.2	*	NS
Total valeric acid	84	103	94	93	6.7	P=0.09	NS
Acetate:Propionate ratio	2.8	2.1	2.4	2.5	0.17	*	NS
NGR ³	4.3	3.5	3.7	4.2	0.34	NS	NS

¹For n=8; ²C, M = Significance level of concentrate proportion (C) and method of feeding (M) effects; ³Non-glucogenic ratio ((acetic acid + (2*butyric acid))/propionic acid). There were no significant concentrate proportion x feeding method interactions.

Table 52: Mean rumen pool sizes and fractional clearance (Kcl) rates

	Concentrate proportion (C)		Method of feeding (M)		s.e.m. ¹	Significance ²	
	Low	High	FED	CEM		C	M
<i>Rumen pool size (kg)</i>							
Liquid (fresh)	73.2	67.6	72.0	68.9	3.70	NS	NS
DM	9.8	10.9	11.0	9.7	0.61	NS	NS
OM	9.0	10.0	10.1	8.9	0.57	NS	NS
NDF	7.0	6.4	6.5	6.9	0.39	NS	NS
<i>Fractional clearance (Kcl) rates (%/h)</i>							
Kcl _{DM}	3.3	5.0	4.7	3.6	0.69	NS	NS
Kcl _{OM}	4.8	7.3	6.9	5.2	1.0	NS	NS
Kcl _{NDF}	2.1	4.5	3.7	2.9	0.52	*	NS

^{1,2}See footnotes to Table 49. There were no significant concentrate proportion x feeding method interactions.

Table 53: Blood metabolites of animals in the blood metabolite study

	Treatment ¹								s.e.m. ²	Time	Treatment x Time	Significance of contrasts ³		
	SO	FL	FM	FH	EL	EM	EH	AL				L	Q	M
<i>Blood metabolites (mmol/l)</i>														
Glucose	4.10	4.36	4.53	4.56	4.19	4.26	4.32	4.44	0.125	***	**	*	NS	*
βHB	0.21	0.30	0.34	0.30	0.26	0.36	0.40	0.22	0.019	***	***	NS	***	NS
Urea	3.52	3.66	4.18	4.71	3.31	3.92	3.76	5.47	0.149	***	***	***	***	***

^{1,2,3} See footnotes to Table 49.

There were no significant concentrate proportion x feeding method interactions.

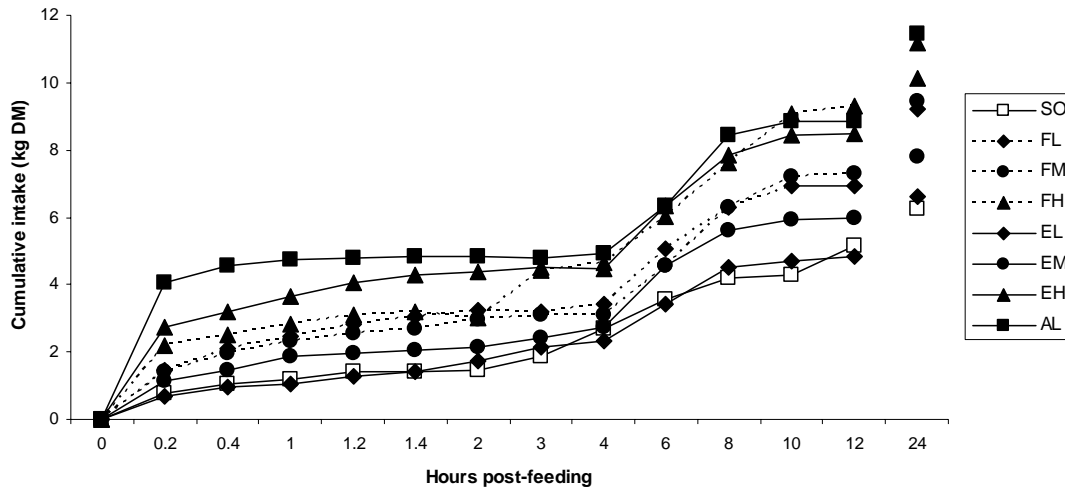


Figure 9. Cumulative total intake (kg DM) for 24 h after feeding.

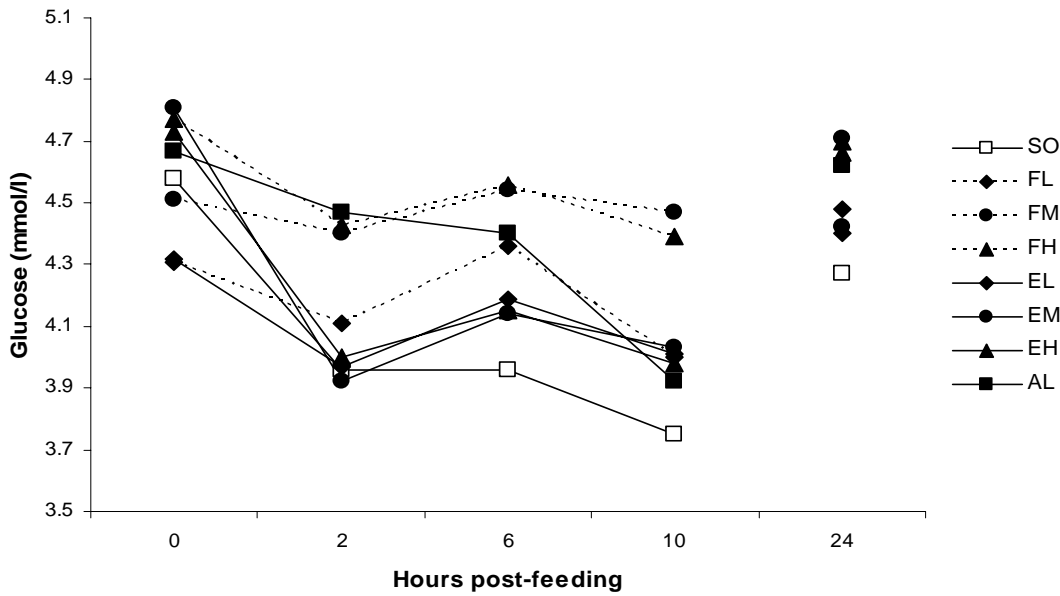


Figure 10. Effect of treatment and sampling time on plasma glucose concentrations (mmol/l).

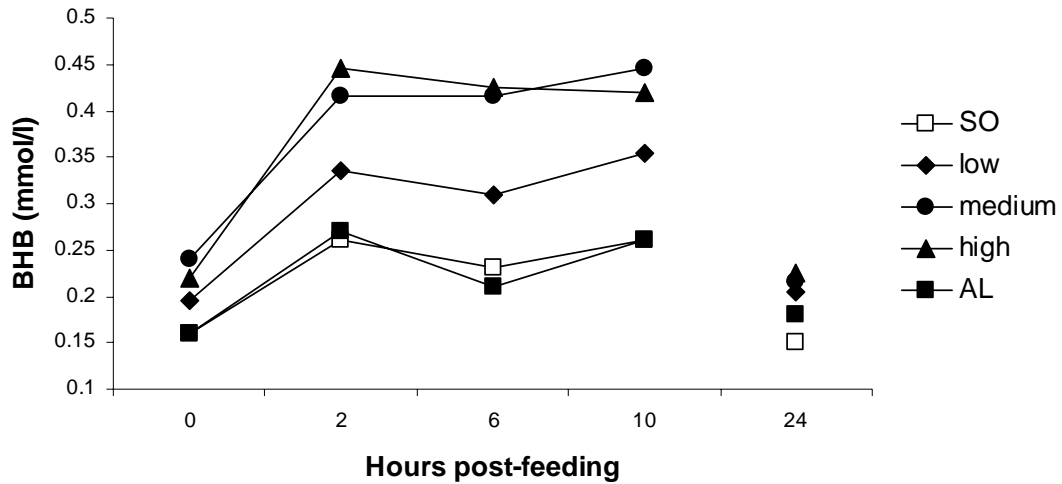


Figure 11. Effect of concentrate proportion and sampling time on plasma β -hydroxybutyrate (β HB) concentrations (mmol/l).

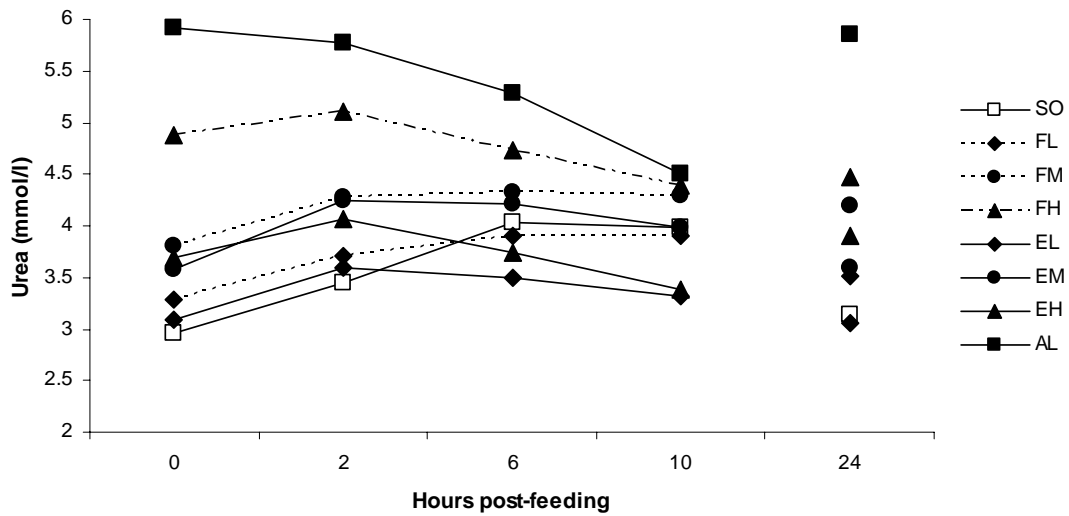


Figure 12. Effect of treatment and sampling time on plasma urea concentrations (mmol/l).

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