End of Project Report

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CONCENTRATE SUPPLEMENTATION OF PASTURE FOR BEEF PRODUCTION

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SUMMARY

* Unsupplemented cattle offered a high grass allowance (18 kg (DM)/head/day), achieved 0.97 of the DM intake of a positive control offered concentrates ad-libitium. At a low grass allowance (6 kg/DM/head/day), there was no effect of supplementary concentrates on grass intake. At a medium (12 kg/DM/head/day), and high grass allowance, supplementary concentrates reduced grass intake by 0.43 and 0.81 kg/DM respectively per kg/DM concentrate offered.

* Supplementary concentrates increased complete diet digestibility even though offering supplementary concentrates also increased total DM intake. Complete diet digestibility was higher than the additive values of the grass and concentrates. This would imply that the supplementary concentrates increased the grass DM digestibility.

* Increasing the grass allowance increased plasma urea concentration; supplementary concentrates increased total dietary nitrogen intake and reduced plasma urea concentration. These findings suggest that the concentrate supplement enabled greater utilisation by rumen micro-organisms of the degradable nitrogen supplied by the grass.

* Supplementing with concentrates increased carcass growth by 116 g/kg concentrate DM eaten whereas increasing the grass allowance increased carcass growth by 38 g/kg/DM grass eaten. The carcass weight response to concentrates of grazing animals was twice that of animals offered concentrates ad-libitum which gained 57 g carcass per kg concentrate DM eaten.

* The relationship between carcass gain (Y) (kg/day) and supplementary concentrates (X) (kg/day) was quadratic ($P < 0.001$) and was best described by the equation: $Y = -0.0099X^2 + 0.1364X + 0.2459$ ($R^2 = 0.60$). The relationship between carcass gain (Y) (kg day-1) and grass intake (X) was also quadratic ($P < 0.01$) and was best described by the equation: $Y = -43X^2 + 275X + 133$ ($R^2 = 0.48$).

* Although there was a much larger (double) carcass growth response to supplementary concentrates than to additional grass DM eaten, increasing grass intake significantly increased carcass fat scores whereas offering supplementary concentrates did not. This would imply that relative to concentrates, autumn grass led to a change in the partitioning of energy from muscle towards subcutaneous fat.

* As a strategy for increasing the performance of cattle grazing the type of autumn grass used in this study, offering supplementary concentrates offers more scope to improve animal performance than altering grass allowance.

* The carbohydrate source of the three concentrates formulated to differ in rate of degradability did not alter rumen fluid pH, volatile fatty acid (VFA) concentration or the rate of grass DM or N degradation when grass supply was considered to be limiting or liberal. The autumn grass was apparently capable of buffering the effects of concentrate DM degradation rate which varied by up to two fold.

* The rumen fluid parameters were more influenced by the pattern of grass intake than type of concentrate offered. Hence, there was no effect of concentrate type on animal performance.

INTRODUCTION

Feed costs are a major proportion of total variable costs in beef systems and grazed grass is generally the cheapest feedstuff available. Achieving high annual intakes of grazed grass can therefore reduce beef production costs. Grass growth varies widely throughout the year and, as growth declines in the autumn, herd demand often exceeds the supply of feed. Performance by grazing cattle is frequently poor on farms after mid-summer. This may be related to the quantity and/or quality of grass available relative to the requirements of the grazing animals. At similar digestibility values, autumn grass has a lower metabolizable energy content, net energy and feeding value and intake than grass grown earlier in the season. Nutrient intake from autumn grass may thus be insufficient to support animal liveweight gains achieved early in the grazing season. Additional feedstuffs are necessary if rapid daily liveweight gains are to be maintained.

Previous work with grazing cattle showed that where pasture supply was adequate or where animals were at low stocking rates, there was no significant animal production response to supplementary concentrates. However, when pasture supply or quality was limiting there was an animal growth response to feeding concentrates. These trials evaluated supplementation in either the early part of the grazing season when grass quality is generally good, or throughout the entire grazing season, and thereby did not quantify the potential of supplementation in autumn. In relation to beef finishing, little information is available on supplementing autumn grazed grass with concentrates. Two strategies that could potentially increase animal performance from autumn grass are (a) an increase in the supply of grass or (b) introduction of additional feedstuffs such as supplementary concentrates.

Three experiments were carried out in the current project. The objective of the first experiment was to quantify the relationship between grass supply and concentrate supplementation level and their effects on grass intake and steer performance in the autumn. The aim of the second study was to determine the effects, on animal performance, of supplementing grazed grass with concentrates and managing cattle at pasture as a single group or as separate leader and follower groups. The objective of the third study was to determine the effects of autumn grass supply and supplementary energy concentrate carbohydrate source on the growth rate and rumen digestion characteristics of beef cattle.

Autumn grass is characterised by a low water soluble carbohydrate concentration and high levels of rumen degradable protein. An excess of rumen-degradable protein and the consequential need to excrete large amounts of urea has a negative effect on the energy balance of animals. Energy supplements offer the opportunity to restore the balance between rumen degradable nitrogen and rumen fermentable energy and thus facilitate optimum microbial capture of degraded N. High inputs of rapidly fermentable substrates, such as soluble sugars or starch, can increase the concentrations of volatile fatty acids (VFA) and lactate in the rumen, thereby causing a marked decrease in pH. This can reduce cellulolytic activity among rumen microbes, resulting in a lower rate of forage fibre digestion and thus an increase in retention time in the rumen, which in turn can restrict feed intake. However, in the autumn, due to declining grass growth, grass supply may be a more limiting factor to grass intake than is the rate of its digestion in the rumen.

Experiment 1: Intake and Growth of Steers offered different allowances of Autumn Grass and Concentrate.

Materials and Methods

Experimental design

One hundred and ten continental crossbred steers (567 (s.d. 32.3) kg mean initial liveweight) were blocked on weight and assigned at random from within blocks to one of ten treatments. Nine treatments were arranged in a three (grass allowances) by three (concentrate level) factorial. The three daily grass allowances were 6 (low), 12 (medium) and 18 (high) kg dry matter (DM) /head and the daily concentrate allowances were 0, 2.5 and 5 kg fresh weight/head. A tenth treatment group (positive control) was accommodated indoors and individually offered concentrates ad-libitum and had free access to an outdoor environment without grass. The experiment continued for a mean duration of 95 days from 22 August.

Grazing management

Daily grass allowances were achieved by varying the size of the grazing area. Animals were offered a fresh allowance daily and did not have access to the previous days allowance. Pre-grazing grass mass was estimated by cutting four strips three times weekly from the areas to be grazed by each treatment group. Post-grazing grass mass was estimated three times weekly by cutting 4 strips to a 4cm stubble height, from the area grazed by the steers on each treatment. All plots were subsequently grazed to a constant (4 cm) post-grazing mass by animals not on this experiment. Grass intake using the n-alkane techniqueand diet digestibility ytterbium as a faecal output marker were estimated over two three-day periods (days 82-85 and 86-88) for each treatment.

Concentrate feeding

A pelleted concentrate, which was a mixture of ground barley (0.29), unmolassed beet pulp (0.29), maize gluten (0.29), soya-bean meal (0.05), molasses (0.05) and mineral/vitamin mix (0.03), was offered individually to all animals receiving supplementary concentrates. The appropriate animals were restrained individually in a purpose built mobile feeder in the field and offered 2.5 kg concentrates per head at 0800h, before being allocated a fresh daily grass allowance. Animals remained restrained until the concentrates were consumed (approximately 20 min.). Animals receiving 5 kg concentrates daily were offered a further 2.5 kg concentrates at 1600h. The control group of animals was offered concentrates ad-libitum indoors, following a 12-day adjustment period, and 1 kg straw, through electronically controlled gates.

Results

Feed composition

The chemical composition of the grass and concentrates used are shown in Table 1. The concentrate had calculated protein digested in the small intestine when nitrogen is limiting microbial protein synthesis (PDIN) and protein digested in the small intestine when energy is limiting microbial protein synthesis (PDIE) values of 108 and 112 g/kg/DM and a calculated net energy value of 1.08 UFL (l)/ kg/DM.

Table 1. Chemical composition[1] of grass and concentrates offered

	Grass[2]	Concentrate[3]
Dry matter (g/kg)	198 (23)	872 (7)
Crude protein (g/kg dry matter (DM))	225 (25)	143 (4)
Acid detergent insoluble nitrogen (g/kg DM)	4.7 (1.5)	
Neutral detergent insoluble nitrogen (g/kg DM)	11.8 (2.5)	
Ash (g/kg DM)	125 (53)	48 (1.2)
In-vitro DM digestibility (g/kg)	738 (52)	
Organic matter digestibility (g/kg)	729 (52)	844 (11)
Crude fibre (g/kg DM)	287 (64)	101 (1.1)
Oil (g/kg DM)	29 (4.0)	24 (1.8)
Acid detergent fibre (g/kg DM)	257 (22)	152 (8)
Neutral detergent fibre (g/kg DM)	428 (41)	535 (53)

[1]mean (s.d.), [2]n=29, [3]n=15.

Grass intake and diet digestibility

There was an interaction ($p<0.05$) between grass allowance and concentrate level for grass intake ($p<0.05$) and complete diet digestibility ($p<0.001$) (Table 2). At the low grass allowance, there was no effect of supplementary concentrates on grass intake, however at the medium and high grass allowances, supplementary concentrates reduced grass intake. Grass allowance increased ($p<0.001$) complete diet digestibility only in the absence of concentrates and supplementary concentrates increased ($p<0.001$) complete diet digestibility only at the low grass allowance.

Animal performance

An increased grass allowance increased final liveweight ($p<0.001$) and liveweight gain ($p<0.001$) (Table 3). Offering supplementary concentrates also increased final liveweight ($p<0.001$) and liveweight gain ($p<0.001$). There was no significant interaction between the effects of grass allowance and concentrate level on final liveweight or liveweight gain. Animals offered supplementary concentrates had higher ($p<0.001$) kill-out proportion (approximately 20g/kg liveweight). Grass allowance did not affect kill-out proportion nor was the positive control group of animals significantly different from any other group. Supplementary concentrates ($p<0.001$) and increasing their grass allowance ($p<0.001$) increased carcass gain and final carcass weight. There was no significant interaction between the effects of grass allowance and level of concentrates offered on the animal carcass gain. The positive control group of animals had higher ($p< 0.05$) carcass gain than all other treatments except the treatment offered the high grass allowance and 5 kg concentrate.

Carcass traits

Supplementary concentrates increased ($p<0.001$) carcass conformation scores. The animals offered concentrates ad-libtium had a higher ($p<0.05$) conformation score than all the unsupplemented animals, but did not significantly differ from the supplemented animals.

Increasing the grass allowance increased ($p<0.05$) carcass fat scores. However, offering animals supplementary concentrates did not significantly alter their carcass fat scores. Both KCF weight and KCF as a proportion of carcass weight, were increased by offering

Table 2. The effect of grass allowance and concentrate level of intake, diet digestibility.

	Grass allowance													
	6kg/hd/day			12 kg/hd/day			18 kg/hd/day			Control	s.e.	H	C	HxC
	0kg	2.5kg	5kg	0kg	2.5kg	5kg	0kg	2.5kg	5kg	12.53kg				
Grass intake (kgDM/day)[1]	5.29	5.40	5.23	9.28	7.98	7.34	12.95	9.42	9.27		0.332	***	***	*
Total DM intake (kg/day)[2]	5.29	7.65	9.72	9.28	10.23	11.83	12.95	11.67	13.76	13.33				
Diet DM digestibility (g/kg)[3]	754	838	855	881	860	888	9202	888	897		7.4	***	***	***
Digestibile DM intake (kg/day)	4.01	6.71	8.77	7.14	8.41	10.19	9.57	10.12	11.64		0.488	***	***	n.s.
Post grazing digestibility (g/kgDM)		459	527	533	592	629	627	629	648	669				
Digestibility of grass eaten (g/kgDM)		0.758	0.772	0.773	0.758	0.772	0.773	0.758	0.772	0.773				
Grass intake (kgDM/day)[4]	5.59	5.16	5.13	9.37	9.16	8.44	12.46	11.87	10.76					

[1]Estamited individually using n-alkanes, [2]Estimated using individual faecaloutput and individual grass intake, [3]Estimated from the difference between digestibility of pre-and post-grazing mass and the proportion consumed, [4]Estimated per treatment group from the pre- and post-grazing herage mass.

Table 3. The effect of grass allowed and concentrate level feed efficiency, animal growth, and carcass characteristics.

	Grass allowance													
HxC	6kg/hd/day			12 kg/hd/day			18 kg/hd/day				Control	s.e.	H	C
	0kg	2.5kg	5kg	0kg	2.5kg	5kg	0kg	2.5kg	5kg	12.53kg				
Final liveweight gain (g/day)	583	620	654	619	643	669	641	688	676	703	11.38	***	***	n.s.
Liveweight gain (g/day)	140	540	940	530	780	1060	750	1050	1140	1430	64.2	***	***	n.s.
Carcass weight (kg)	304	332	352	323	348	361	330	355	363a1	371	5.49	***	***	n.s.
Carcass gain/day (g)	88	393	617	290	551	695	360	631	727a	809	24.0	***	***	n.s.
Feed efficiency[2] (g/kg)	22	59	71	41	66	69	38	62	63					
Kill-out proportion (g/kg)	522a	537a	538a	521a	541a	540a	515a	532a	538a	528	4.0	n.s.	***	n.s.
	4.0													
Carcass conformation[3]	2.27	2.73	3.18a	2.64	3.09a	2.91a	2.73a	3.09a	3.09a	3.09	0.141	0.069	***	0.069
Fat score[4]	3.73	3.79	3.79	3.85	4.15	3.91	4.03	3.97	4.14	4.64	0.108	*	n.s.	n.s.
KCF (kg)[5]	5.05	7.35	8.82a	6.79	7.57	8.93a	7.93	9.19a	10.25a	10.69	0.301	**	***	n.s.
KCF/carcass (g/kg)	17	22	25	21	22	25	24	26	28a	29	2.1	*	**	n.s.

[1]Values with subscript, awere not significantly different ($p<0.05$) from ad libitium concentrate group, [2]E Daily carcass gain/digestiible DM intake, [3]1 = pooorest, 5 = best, ; [5]KCF = kidney plus channel fat

animals supplementary concentrates ($p<0.01$) and by increasing the grass allowance ($p<0.05$).

Conclusion

Assuming that the growth potential of the cattle was realised by the ad-libtium concentrate group, grazed grass, at an allowance of 30g DM/kg bodyweight, only supported 0.45 of the potential carcass growth. Per kg of DM eaten, grass supported only one third the carcass growth of supplementary concentrates. As a strategy for increasing the performance of cattle grazing autumn grass, offering supplementary concentrates offers more scope than altering grass allowance.

Experiment 2: The effect of system of herbage allowance and concentrate supplementation on beef production from autumn grass

Materials and Methods

Sixty continental-crossbred steers (mean initial liveweight 504(s.d. 38.4) kg) were blocked according to weight and assigned at random, within blocks, to one of six treatments. Three treatment groups were offered a daily herbage supply of 11 kg dry matter (DM), plus either 0 (control), 2.5 or 5.0 kg concentrates per head daily. Each group of animals rotationally grazed a separate 2 ha area of grassland and were offered fresh herbage daily. A fourth treatment group had access to an outdoor environment without grass while being individually offered concentrates ad-libitum and 1 kg straw indoors. The fifth and sixth treatment groups were managed as leader and follower grazers respectively and rotationally grazed a total of 4 ha. The leaders were offered a herbage allowance of 22 kg grass DM per head daily with the followers grazing the residual herbage the following day. Neither of these treatment groups were supplemented with concentrates and both could be compared with the first treatment group (i.e. control) above where animals received a similar mean allocation of grass DM but were not separated into leaders and followers. The experiment commenced on August 22 and had a mean duration of 84 days. Animals from the five heaviest blocks were slaughtered after 80 days and those from the remaining five blocks after 88 days. A pelleted concentrate mixture of ground barley (0.46), unmolassed beet pulp (0.42), soya bean meal(0.05), tallow (0.02) and mineral/vitamin pre-mix (0.05), was offered individually to all animals. Animals receiving supplementary concentrates were constrained individually in a mobile feeder in the field, offered 2.5 kg concentrates per head at 0800 and were then allocated the fresh daily herbage allowance. Animals receiving 5 kg concentrates daily were similarly offered a further 2.5 kg concentrates at 1600h.

Results

Grass measurements and animal performance

Estimated herbage DM intake was highest for the leaders and lowest for the followers (Table 4). Animals supplemented with concentrates tended to have lower herbage DM intakes than the control treatment and higher post-grazing herbage DM yields. The dry matter degradeability (DMD), organic matter digestibility (OMD) and crude protein (CP), for both pre- and post-grazing swards were highest for the leader treatment and lowest for the follower treatment. The same variables were also higher pre-grazing than post-grazing, and for post-grazing tended to be slightly higher for the concentrate supplemented treatments than for the control treatment. The group offered concentrates ad-libitum consumed 11.13 (s.d. 0.46) kg of concentrate DM/head daily.

The highest ($p<0.05$) liveweight gain was achieved by the ad-libitum concentrate group and the lowest ($p<0.05$) was achieved by the follower treatment (Table 5). The group offered 5 kg concentrate had a higher ($p<0.05$) liveweight gain than the group offered 2.5 kg concentrate, or than the leader or control groups.

Each increment of supplementary concentrates increased carcass gain ($p<0.05$) and carcass ($p<0.05$). The leaders had a heavier ($p<0.05$) carcass weight and higher carcass gain ($p<0.05$) than the control group but did not differ from the group supplemented with 2.5 kg concentrates. Carcass growth rate of the steers offered ad-libitum concentrates was higher ($p<0.05$) than that of the control or 2.5 kg concentrate groups but did not differ from the 5 kg concentrate treatment. Carcass growth for the followers was lower ($p<0.05$) lower than all other treatments. The 2.5 kg and 5 kg concentrate treatment groups had higher ($p<0.05$) carcass conformation scores than the control or the follower treatments. The leaders and the ad-libitum concentrate group were intermediate and did not differ from the other treatments. The followers had lower ($p<0.05$) carcass fat scores than all other treatments except the control. The followers and the control groups had the lowest weights and proportions of KCF. The first concentrate increment significantly increased the weight but not the proportion of KCF in the carcass compared with controls. The ad-libitum concentrate group had the highest weight and proportion of KCF although they did not differ from those of the leaders or the 5 kg concentrate group.

Conclusion

Assuming that the growth potential of the cattle was realised by the ad-libitium concentrate group, grazed grass, at an allowance of

20 g DM/kg bodyweight, only supported half the potential carcass growth rate. Changing the grazing management strategy, to a leader/follower system, to allow the leaders an allowance of 40 g DM/kg bodyweight supported 75 % of potential carcass growth rate. While the grass available to the followers only supported maintenance. The alternative strategy of supplementing grazing cattle with concentrates improved growth rates, with 5 kg supplementary concentrates supporting carcass growth rates similar to the ad-libtium concentrate treatment. It is concluded that under the conditions prevailing in this experiment that supplementing with concentrates rather than changing the autumn grazing management system provided the best opportunity to achieve maximal carcass growth rates.

Table 4. The effect of grazing system and concentrate level on mean (s.d.) herbage pre- and post-grazing yield, chemical composition and estimated intake.

	Treatment				
	Control	2.5kg concentrate		5kg concentrate	Leaders
Followers					
Area/group/day (m^2)	385 (65)	378 (53)	371 (54)	801 (187)	801 (187)
Yield (kg dry matter (DM)/ha)					
Pre-grazing	2860 (670)	2912 (634)	1038 (633)	1125 (218)	1125 (218)
Post-grazing	746 (158)	857 (179)	1038 (178)	1125 (218)	360 (130)
Herbage DM intake (kg/head/day)	7.90 (1.31)	7.59 (1.07)	7.00 (0.90)	12.58 (1.61)	3.18 (1.09)
Organic matter digestibility (g/kg/DM)					
Pre-grazing	880 (15.2)	875 (30)	886 (16)	890 (14)	846 (26)
Post-grazing	815 (46)	837 (40)	836 (27)	846 (25)	687 (82)
Dry matter digestibility (g/kgDM)					
Pre-grazing	729 (18.6)	731 (30)	741 (18)	742 (21)	675 (36)
Post-grazing	596 (64)	641 (57)	629 (30)	675 (36)	546 (94)
Crude protein (g/kgDM)					
Pre-grazing	227 (38)	231 (41)	241 (28)	243 (35)	192 (28)
Post-grazing	167 (36)	180 (35)	188 (26)	192 (28)	163 (28)

Table 5. Effect of grazing system and concentrate level on liveweight gains and carcass traits

	Grazing treatments					*Ad-libitum*		
	Control	2.5kg concentrate	5kg concentrate	Leaders	Followers	concentrate	SEM	Significance
Liveweight gain (g/day)	519^{d}	718^{cd}	1138^{b}	788^{c}	25^{c}	1371^{a}	76.2	***
Kill-out (g/kg)	533	542	549	531	526	540	7.0	n.s.
Carcass weight (kg)	307.4^{c}	329.6^{b}	348.0^{a}	322.2^{b}	277.2^{d}	343.4^{a}	4.10	***
Carcass gain (g/day)	392^{d}	657^{cd}	877^{a}	549^{c}	3^{c}	790^{ab}	46.8	***
Carcass conformation≈	2.20^{b}	2.90^{a}	2.90^{a}	2.60^{ab}	2.10^{b}	2.60^{ab}	0.168	***
Carcass fatness score∆	3.73^{ab}	4.00^{cd}	4.13^{a}	3.93^{a}	3.13^{b}	4.20^{a}	0.222	*
KCF[4]	5.21^{c}	8.15^{b}	9.64^{ab}	8.63^{ab}	3.31^{c}	10.49^{a}	0.0691	***
KCF (g/kg carcass)	17^{bc}	25^{ab}	28^{a}	27^{a}	12^{c}	31^{a}	3.1	***

◊Kill-out rate was estimated as the cold carcass weight as a proportion of the final liveweight
≈1 = poorest, 5 = best; ∆1 = leanest 5 = fattest; [4]KCF = kidney plus channel fat ;
Means in rows without a common superscript are significantly different (P<0.05)

Experiment 3 : Animal Performance and Rumen Digestive Characteristics of Steers Grazing Different Allowances of Autumn Grass and Supplemented with Concentrates Formulated from Different Carbohydrate Sources.

Materials and Methods

Experimental design

Seventy-two continental crossbred steers (mean initial liveweight 494 (s.e. 38.4) kg) were blocked on bodyweight and assigned at random from within blocks to one of six treatments. The treatments were arranged in a two (grass allowances: 5.5 or 11 kg grass DM/head/day), by three (concentrate types: starch, starch + fibre and fibre based rations), factorial design. The experiment commenced on August 22 and had a mean duration of 84 days.

Feed allowance and degradability

Daily grass allowances were achieved by varying the size of the grazing area. Animals were offered a fresh allowance daily and did not have access to the area grazed on the previous day. Pre-grazing grass mass was estimated by cutting and weighing four samples of grass (each 1.2 m x 5 m; 4 cm stubble height) three times per week from the areas to be grazed by each treatment group. Sub-samples were used to determine DM concentration. The supplementary pelleted concentrates were formulated to be iso-energetic and iso-nitrogenous from the ingredients described in Table 6.

Table 6. Ingredient formulation (g/kg) of the concentrates

Ingredient	Starch	Starch + fibre	Fibre
Barley	902	459	0
Unmolassed beetpulp	0	419	849
Soybean meal	62	83	106
Tallow	0	10	22
CalPhos◊	3.2	8.2	13.5
Limestone≈	21	11	0.2
NaCl	8.6	7.1	5.6

◊0.25 calcium, 0.20 phosphorous. ≈0.38 calcium

The grass samples for degradability were taken three days before the respective treatments were grazed. They were cut to the height to which cattle on the respective treatments were grazing and were then dried at 40oC for 48h. Concentrate degradability was measured using a separate group of 3 fistulated steers (640 kg) each offered a diet of 5 kg of the starch + fibre concentrate (Table 1) and 20 kg of grass silage (fresh weight) (DM 224 g/kg, DMD 725 g/kg, and CP 149 g/kg DM). Dry matter (DM) degradability of the concentrate was measured using the same procedure as for grass DM degradability. The concentrates were ground through a 2 mm screen and 12 nylon bags of each concentrate (1.5 g) were incubated in the rumen of each animal.

Rumen measurements

Six steers of similar age, weight and breed type to those above were each fitted with a rumen cannula five weeks prior to the start of experiment. At the start of the experiment , one fistulated steer was assigned to each of the six grazing treatments for a period of 14 days and subsequently rotated among the other five treatments in a Latin Square (six periods x six animals x six diets) arrangement of treatments. The fistulated animals were allowed 12 days to adjust to their respective treatments. At 0800h on day 13, to measure grass degradability, a set of 12 nylon bags were placed in the rumen. Two bags were removed, 2, 4, 8, 12, 24 and 48 h later.

Rumen fluid samples were taken at each time point at which nylon bags were removed. Rumen fluid pH was measured in each sample immediately after collection. In addition, a 20 ml rumen fluid sample was mixed with 0.5 ml of 50% (w/v) sulphuric acid and stored at -20oC until analysed for volatile fatty acid (VFA), ammonia and L-lactic acid concentration.

Results

Feed composition

The chemical composition of the grass and concentrates used are shown in Table 7. The CP concentration of all the concentrates was similar. The digestibility of the concentrates increased with increasing proportion of fibre.

Rumen fluid

There was no significant effect of grass allowance or concentrate type on any of the rumen fermentation variables presented in

Table 7. The chemical composition of the feeds offered

	Grass	Concentrates		
		Starch	Starch+ fibre	Fibre
Protein (g/kg DM)	214	154	159	158
Water soluble carbohydrates (g/kg DM)	95	24.5	47.2	70.6
Starch (g/kg DM)		454	228	0
Oil (g/kg DM)	29.1	24.8	26.2	29.3
Crude fibre (g/kg DM)	22.1	41.7	76.6	106.6
In-vitro dry matter digestible (g/kg DM)	720	829	857	866
Ash (g/kg DM)	132	51.4	75.6	90.4
NDIN (g/kg DM)◊	16.2	20.2	19.0	17.0
ADIN (g/kg DM)≈	15.4	31.1	30.3	25.9

◊Neutral detergent insoluble nitrogen, ≈Acid detergent insoluble nitrogen

Table 8. However, there was a diurnal effect ($p < 0.001$), for all variables. Acetate and valerate as a proportion of total VFA, was lowest 2 and 4 hours after each concentrate feed. There was an interaction ($p < 0.05$) between daily grass allowance and time of sampling for the acetate: propionate ratio (Figure 1), with a larger decrease occurring in the acetate: propionate ratio of the animals offered the low grass allowance relative to those offered the high grass allowance.

Feed degradability

The insoluble fraction of the starch based concentrate was degraded more rapidly ($p<0.001$) in the rumen, but had a lower ($p<0.001$) instantly degradable fraction and was less extensively ($p<0.01$) degraded than the fibre/starch concentrate or the fibre based concentrate (Table 9). There was no effect of concentrate type or grass allowance on the degradation rate or extent of degradation of the DM or nitrogen fractions of grass.

Animal performance

Animals offered the high grass allowance had higher liveweight gains ($p<0.001$), carcass weights ($p< 0.01$) and carcass gains per day ($p< 0.01$) than the animals offered the low grass allowance. There was no effect ($p> 0.05$) of grass allowance on kill-out rate carcass conformation, fat score or KCF as a proportion of carcass weight (Table 10).

There was no effect ($p > 0.05$) of concentrate type on the live or carcass characteristics measured except KCF as a proportion of carcass weight. The animals offered the starch based concentrate had lower ($p<0.05$) levels of KCF relative to the treatments offered the starch + fibre or the fibre based concentrates.

Conclusion

The concentrates were formulated to differ in rate of degradability and the starch-based concentrate was degraded at approximately twice the rate of the fibre-based concentrate. The carbohydrate source of the concentrate did not alter rumen fluid pH, VFA concentration or the rate of grass DM or N degradation when grass supply was considered to be limiting or liberal. The autumn grass was apparently capable of buffering the effects of concentrate DM degradation rate. The rumen fluid parameters were apparently more influenced by the pattern of grass intake than type of concentrate offered. Hence, there was no effect of concentrate type on animal performance.

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Table 8. The effect of grass allowance and concentrate type on rumen fermentation variables

	Grass allowance (G)		CONCENTRATE TYPE (C)						Time (T)									
	5.5 kgDM	11 kgDM	Starch	Starch +fibre	Fibre	0	2	4	8	12	24	G	C	T	GxC	GxT	CxT	s.e.
pH	6.64	6.67	6.66	6.66	6.65	7.11	6.39	6.16	6.37	6.18	7.0	n.s.	n.s	***	n.s.	n.s	n.s.	0.800
L-lactic acid[1]	920	938	967	873	947	573	2219	1036	493	1018	690	n.s.	n.s.	***	n.s.	n.s.	n.s.	43.4
Ammonia[1]	15.1	13.9	14.2	14.7	14.5	12.2	25.4	20.0	9.1	8.1	13.6	n.s.	n.s.	***	n.s.	n.s.	n.s.	2.80
Total VFA[2]	86.6	89.2	84.9	89.9	88.9	60.3	99.8	115	98.5	123	57.4	n.s.	n.s	***	n.s	n.s.	n.s.	5.80
Acetate[3]	660	661	662	658	661	683	652	638	639	627	692	n.s.	n.s.	***	n.s.	n.s.	n.s.	8.2
Propionate[3]	184	187	189	183	186	172	198	202	202	211	155	n.s.	n.s.	***	n.s.	n.s.	n.s.	13.6
Butyrate[3,4]	133	128	125	137	132	122	129	137	139	143	128	n.s.	n.s.	***	n.s.	n.s.	n.s.	12.4
Valerate[3,5]	21	23	24	22	21	24	21	22	20	19	26	n.s.	n.s.	***	n.s.	n.s.	n.s.	3.6
Acet.. prop. ratio	3.69	3.61	3.62	3.69	3.65	4.09	3.33	3.18	3.21	3.01	4.55	n.s.	n.s.	***	n.s.	*	n.s.	0.302
Plasma																		
BHB[2]	0.228	0.266	0.277	0.269	0.284	0.18	n.d.	0.33	0.28	0.32	n.d.	n.s.	n.s.	***	n.s.	n.s.	n.s.	0.0181
Glucose[2]	4.31	4.30	4.33	4.25	4.33	4.24	n.d.	4.19	4.31	4.47	n.d.	n.s.	n.s	***	n.s.	n.s.	n.s	0.052
Urea[2]	4.19	4.09	4.13	4.21	4.10	4.17	n.d.	4.65	4.13	3.61	n.d.	n.s.	n.s.	***	n.s.	n.s.	n.s	0.1079

[1]mg/l, 2mmol/l, [3]mol/1000 mol VFA, [4]butyrate + isobutyrate, [5]valerate and isovalerate, [6]not determined, [7]s.e. for G x C interaction

Table 9. The effect of grass allowance and concentrate type on grass dry matter and nitrogen degradability and the effect of concentrate type on concentrate dry matter degradability

Concentrate type (C)	Starch		Starch + fibre		Fibre		G	C	GxC	s.e.
Grass allowance (G) (kgDM/head)	5.5	11	5.5	11	5.3	11				
Grass dry matter◊										
Degradation rate of insoluble fraction (/h)	0.059	0.069	0.063	0.059	0.052	0.060	n.s	n.s	n.s	0.0031
Instantly degradable fraction (g/kg)	480	476	470	486	489	447	n.s	n.s	n.s	19.5
Total degradable fraction (g/kg)	866	857	825	878	875	845	n.s	n.s.	n.s	28.6
Grass nitrogen◊										
Degradation rate of insoluble fraction (/h)	0.073	0.090	0.102	0.087	0.068	0.085	n.s	n.s	n.s	0.0199
Instantly degradable fraction (g/kg)	404	427	360	425	395	416	n.s	n.s	n.s	41.1
Total degradable fraction (g/kg)	895	886	866	892	905	872	n.s	n.s	n.s	39.6
Concentrate dry matter≈										
Degradation rate of insoluble fraction (/h)	0.189		0.102		0.094			***		0.0114
Instantly degradable fraction (g/kg)	375		422		513			***		24.7
Total degradable fraction (g/kg)	872		927		937			**		21.9

◊Determined using companion fistulated animals at pasture - see text for details
≈Determined indoors using silage as basal diet - see text for details

Table 10. The effect of grass allowance and concentrate type on live animal and carcass characteristics

Concentrate type (C)	Starch		Starch + fibre		Fibre		G	C	GxC	s.e
Grass allowance (G) (kgDM/head)	5.5	11	5.5	11	5.3	11				
Grass dry matter◊										
Liveweight gain (g/day)	918	1200	942	1216	975	1112	***	n.s	n.s	30.0
Carcass weight (kg)	324.3	337.1	321.4	330	325.1	331.0	**	n.s	n.s	2.52
Carcass gain (g/day)	603	756	568	672	612	684	**	n.s	n.s	18.1
Kill-out proportion	0.555	0.555	0.547	0.546	0.551	0.558	n.s	n.s	n.s	0.002
Carcass conformation≈	2.58	2.58	2.42	2.50	2.50	2.58	n.s	n.s	n.s	0.055
Fat score∆	3.44	3.86	3.89	4.16	3.94	3.89	n.s	n.s	n.s	0.076
KCF4/carcass (g/kg)	18	19	24	23	22	26	n.s	*	n.s	1.0

1s.e. for G x C interaction, 21 = poorest, 5 = best ; 31 = leanest 5 = fattest ; 4KCF = kidney plus channel fat

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