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Research Article

The Effect of Concentrate- and Silage-Based Finishing Diets on the Growth Performance and Carcass Characteristics of Suffolk Cross and Scottish Blackface Lambs

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Abstract: In the present study 48 Suffolk × Mule (S × M) and 48 Scottish Blackface (SBF) wether lambs were used in a 2 breeds × 2 diets × 4 replications factorial experiment with 6 lambs per pen. Lambs were offered either a concentrate (CONC) finishing diet (DM: 876 g kg^{-1}, estimated ME: 10.9 MJ kg^{-1} of DM, estimated DUP: 32.4 g kg^{-1} of DM) ad libitum, together with 100 g hay $head^{-1}$ day^{-1}, or silage (SIL) offered ad libitum (D value: 67.2), together with up to 450 g $head^{-1}$ day^{-1} of a concentrate supplement (DM: 888 g kg^{-1}, estimated ME: 10.9 MJ kg^{-1} of DM, estimated DUP: 63.9 g kg^{-1} of DM). Lambs were slaughtered at estimated MLC fat class 2 to 3L. Both breed and diet had a significant effect on daily live weight gain (DLWG) (S × M: 282 vs. SBF: 210 g; CONC: 383 vs. SIL: 109 g) and the food conversion ratio (FCR) was significantly affected by diet (CONC: 5.3 vs. SIL: 7.7). Breed × diet interactions were significant for both DLWG and FCR. Conformation score was better in the S × M lambs than in the SBF lambs (3.2 vs. 2.6; scale E = 5, P = 1), whereas diet influenced the estimated subcutaneous fat proportion (CONC: 121.5 g kg^{-1} vs. SIL: 113.2 g kg^{-1}).

Key Words: Lamb, breed, diet, growth, carcass

Introduction

There is great variation in lamb carcass quality due to the number and diversity of breeds and crosses involved in lamb production. Lamb breed influences the pattern of development of important carcass components and, thus, carcass quality when comparison is made at equal weights. Distinct differences in chemical, physical, and organoleptic properties exist between lambs from different genetic backgrounds (1). Plane of nutrition also affects the growth rate and carcass characteristics of lambs of the same genotype; however, comparative information on growth performance and carcass characteristics of lambs of different breeds is scant. The information available has been obtained largely from practical experience and from commercial recording schemes. It does not relate to lambs of different breeds reared in contemporary groups.

The present study was conducted to investigate the effects of diet on growth performance and carcass characteristics of lambs of 2 breeds. Lambs from 2 common breeds of 2 different systems were used in this experiment. Suffolk × Mule (S × M) lambs represent the predominant lowland cross breed and many such lambs are unfinished at the end of the grazing season. Scottish Blackface (SBF) made up the second breed and these account for the majority of unfinished lambs sold as stores each year at the end of the grazing season on hill farms. Wether lambs were chosen to limit the confounding effects of sex and in many production systems wether lambs are the most likely sex available for finishing. The lambs were finished on 2 commonly used concentrate- and silage-based diets.

Materials and Methods

The study included 48 SBF wether lambs and 48 S × M wether lambs obtained from an upland farm in Northumberland, UK at weaning, and were managed on the same type of pasture from birth (born between 14

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April 1993 and 12 May 1993). They were brought to a lowland Northumberland farm on 16 August 1993. After weighing, they were allocated at random to 16 pens, each containing 6 animals. Pens were allocated to treatments according to a factorial design of 2 breeds × 2 diets × 4 replications; the 2 diets being concentrate (CONC) and silage (SIL). Animals were allowed 10 days acclimatisation before the trial began. During the acclimatisation period the silage group was fed ad libitum and the concentrate group received 200 g of concentrate per lamb per day plus hay ad libitum. The concentrate was then gradually increased and the hay decreased until the end of the acclimatisation period; the lambs received 1.0 kg of concentrate plus 100 g of hay per day.

Silage, a first-cut perennial rye grass sward, was obtained from the university farm. Grass hay was also obtained from the university farm and was used to feed the CONC group at the rate of 100 g per lamb per day to meet their fibre requirements. The analysis of representative samples of silage and hay are given in Table 1. In addition, 2 types of concentrate feed supplied by a commercial feed company (J. Bibby Agriculture Ltd, UK) were used. One feed (Diet A) was used to feed the CONC group as the major diet with the intention to finish the lambs earlier. The other feed (Diet B) was used to supplement the silage for the SIL group lambs. The diets were formulated to specific levels of energy and protein as shown in Table 2.

Live weight of each lamb was recorded at birth and weaning on pasture, and then every week from weaning to slaughter. All the lambs were also condition scored at the time of weighing, as described by Russel (2). Those lambs with a condition score between 2 and 3 were dispatched for slaughter the following day. Lambs were fed in groups of 6 lambs per pen. The CONC group was offered the concentrate (Diet A) ad libitum, and refusals were weighed daily and reused. Hay was offered at the rate of 100 g per lamb per day and total consumption was assumed. Dry matter percentage was determined at fortnightly intervals, both for concentrate and hay. The SIL group was offered the silage ad libitum, and refusals were weighed daily and discarded. Daily dry matter percentage of offered and refused silage samples was calculated. This group was offered only silage for 3 weeks, then supplement (Diet B) was also offered at a daily rate of 100 g per lamb, gradually increasing over a

Table 2. Proximate analysis of concentrate feeds.

	Diet A	Diet B
Dry matter (g kg^{-1} of FM)	876.3	887.8
Oil (g kg-1 of DM)	41.5	38.2
Crude protein (g kg^{-1} of DM)	152.3	221.9
Fibre (g kg^{-1} of DM)	96.4	83.1
Ash (g kg^{-1} of DM)	74.04	84.3
Estimated feed values		
ME (MJ kg^{-1} of DM)	10.9	10.9
Digestible undegradeable protein (DUP) (g kg^{-1} of DM)	32.4	63.9

Table 1. Analysis of silage and hay.

	Silage*		Hay**	
	Mean	SE	Mean	SE
Dry matter (g kg^{-1} of FM)	302	29.1	860	13.6
Ash (g kg^{-1} of DM)	87.2	5.7	63.7	8.4
pH	4.06	0.12	-	-
Crude protein (g kg^{-1} of DM)	139	14.1	95.3	13.9
Ammonia nitrogen (% total nitrogen)	6.56	1.38	-	-
Neutral detergent fibre (g kg^{-1} of DM)	542	21.1	-	-
MAD fibre (g kg^{-1} of DM)	-	-	382	20.63
Estimated feed values				
D value	67.2	1.62	56.6	2.4
ME (MJ kg^{-1} of DM)	10.7	0.25	8.4	0.44
DCP (g kg^{-1} of DM)	82.6	10.56	49.3	12.73

*Mean of 5 samples; **mean of 3 samples.

6-week period to a maximum of 450 g per lamb until slaughter. Total consumption of this supplement was assumed.

Lambs were selected for slaughter at a condition score between 2 and 3 to give a carcass MLC fat class of 2-3L. Final live weight was recorded immediately prior to transporting the lambs to a commercial abattoir located 15 km from the farm. All carcasses were classified according to fat class, conformation score, and carcass weight by the Meat and Livestock Commission (MLC). After overnight chilling the kidneys and kidney knob channel fat (KKCF) were removed from the carcasses and weighed. An outline of the m. longissimus dorsi was traced on translucent paper and then the area was calculated using a planimeter. The mean of 3 readings was taken as the area of the m. longissimus dorsi.

Statistical Analysis

To evaluate the effect of breed and diet on food intake, growth, and food conversion ratio (FCR), an analysis of variance was performed using the general linear model (GLM) for unbalanced data (Minitab). The mean value of each pen was used for daily dry matter intake (DDMI) and FCR. Daily live weight gain from birth to slaughter and from housing to slaughter was calculated by linear regression. The data were analysed as a 2 × 2 factorial design with estimated subcutaneous fat (SFE) as a covariate where this was significant ($P < 0.05$). The model used was breed (S × M and SBF) and diet (CONC and SIL) as the main effects with breed × diet interaction.

Results

In total, 88 animals completed the feeding period and were slaughtered between condition score 2 and 3. In all, 2 lambs died and 6 were excluded from the analysis because they did not finish by the end of the experiment. Both breed and diet influenced DDMI. S × M lambs consumed more dry matter than SBF lambs, and those fed the CONC diet consumed more dry matter than lambs on the SIL diet (Table 3). Breed had no significant effect on FCR, but lambs on the CONC diet had a lower FCR

Table 3. The effect of breed and diet on food intake, growth performance, and carcass characteristics.

	Breed				Diet			
	S × M	SBF	SED	P	CONC	SIL	SED	P
Group data								
Number of pens	8	8			8	8		
Daily dry matter intake (kg)	1.5	1.4	0.02	< 0.001	1.9	1.0	0.02	< 0.001
Daily live weight gain (g)	288	215	8.6	< 0.001	379	124	8.6	< 0.001
Food conversion ratio (kg of DM intake/kg of wt. gain)	6.2	6.8	0.35	NS	5.3	7.7	0.35	< 0.001
Individual data								
Number of lambs	48	40			47	41		
Initial live weight (kg)	35.7	27.6	0.72	< 0.001	32.3	31.0	0.71	NS
Daily live weight gain (g)	282	210	19.1	< 0.001	382	109	19.1	< 0.001
Finishing period (days)*	54.7	69.2	2.90	< 0.001	33.5	90.5	2.90	< 0.001
Age at slaughter (days)*	188.0	195.0	2.75	< 0.05	162.0	220.2	2.75	< 0.001
Final live weight (kg)*	47.6	40.0	0.79	< 0.001	44.6	42.9	0.79	< 0.05
Cold carcass weight (kg)*	20.8	17.2	0.40	< 0.001	19.2	18.9	0.40	NS
Carcass yield	0.44	0.43	0.005	NS	0.43	0.44	0.005	< 0.05
Subcutaneous fat estimate (g kg^{-1})	115.8	118.9	4.10	NS	121.5	113.2	4.10	< 0.05
Eye muscle area (cm^2)	13.7	13.0	0.32	<0.05	13.5	12.9	0.32	NS
Conformation (E = 5; P = 1)*	3.2	2.6	0.12	< 0.001	3.0	2.8	0.12	NS
Kidney knob channel fat (g)*	399	424	24.4	NS	420	403	24.4	NS
Subcutaneous fat depth (mm)*	4.8	4.2	0.33	NS	4.4	4.5	0.33	NS
Kidneys (g)	131.8	144.4	30.35	NS	159.8	116.4	30.35	NS

*Values were adjusted using SFE as a covariate ($P < 0.05$)

than lambs on the SIL diet (P < 0.001). The effect on FCR of the interaction between breed and diet was significant (Table 4); S × M lambs fed the CONC diet were more efficient than SBF lambs, but when fed the SIL diet this was reversed. From housing to slaughter the effect of breed and diet on DLWG was significant (P < 0.001), but an interaction between breed and diet also occurred (P < 0.01). The growth of S × M lambs was better than that of SBF lambs, regardless of diet, but the growth was relatively better with the CONC diet. Both breed and diet significantly affected the finishing period of the lambs (P < 0.001); S × M lambs finished earlier than SBF lambs and lambs fed the CONC diet finished earlier than lambs fed the SIL diet. Since age at the start of the trial was similar, age at slaughter showed a similar trend. Both breed and diet affected FLW of the lambs. S × M lambs were heavier than SBF lambs of the same condition score, and the lambs fed the CONC diet were heavier than lambs fed the SIL diet. S × M lambs had heavier carcasses than SBF (P < 0.001) lambs, but there were no differences based on diet.

Table 4. Significant breed × diet interactions.

	S × M	SBF	SED	P
DLWG (g)				
CONC	449	316	26.9	< 0.01
SIL	115	103		
FCR (kg of DM intake/kg of wt. gain)				
CONC	4.6	5.9	0.35	< 0.05
SIL	7.9	7.6		
KKCF (g)				
CONC	380	460	34.4	< 0.05
SIL	418	387		
SFD (mm)				
CONC	4.4	4.5	0.46	< 0.05
SIL	5.3	3.8	0.46	< 0.05

The breeds did not differ in KO proportion, but lambs finished on the SIL diet had higher KO proportions than lambs finished on the CONC diet. Breed affected conformation of the lambs; S × M lambs had better conformation than SBF lambs. Breed had no significant effect on fat score (SFE), but lambs fed the CONC diet had significantly more fat than lambs fed the SIL diet (P < 0.05). A significant interaction was found for KKCF between breed and diet (P < 0.05); S × M lambs had less KKCF than SBF lambs fed the CONC diet, but those fed the SIL diet had more KKCF. Kidney weights were similar on all treatments. S × M lambs had larger eye muscle area (EMA) than SBF lambs, irrespective of diet (P < 0.05).

Discussion

The silage used in this experiment was of good quality due to its high estimated D value, ME, and digestible crude protein values (Table 1). The CONC group was fed diet A (Table 2) as the main diet along with 100 g of hay per lamb per day to meet the fibre requirements of the animals and to avoid the problems associated with concentrate feeding, such as acidosis and overeating. The SIL group was fed silage only for the first 3 weeks of the finishing period and then supplementation of the silage with concentrate began in order to avoid weight and condition loss. Fitzgerald (3) also offered lambs well preserved silage of 70 D value. The daily intake was low (480 g per head) and live weight gain was not maintained.

The initial and final live weights of the S × M lambs were greater than those of the SBF lambs due to their higher growth rate and mature weight; however, the age of the animals from both breeds at the start of the feeding period was similar. The higher dry matter intake of the S × M lambs could be because their live weight was greater than that of the SBF lambs. The food requirements of animals on similar diets are normally considered to be a function of live weight or metabolic body weight, as reported by AFRC (4).

It is well known that breeds developed for meat production or with a greater mature body size tend to have better growth performance and carcass conformation than undeveloped breeds or those with lower mature body weight (5-9). The findings of this trial confirmed the following: S × M lambs grew more rapidly than SBF lambs and they had better conformation scores than the SBF lambs; S × M lambs consumed more food and had higher growth rates than SBF lambs. Thus, there was little or no significant variation in FCR due to breed. This is in agreement with the results of Woolliams and Wiener (10) who also found significant variation in food intake and growth rate between Suffolk cross and Blackface lambs, but found little or no variation in FCR. Lambs fed the concentrate diet had higher dry matter intake, faster growth, and lower FCR than those fed the silage diet. These results are in agreement with the results of previous studies (11-15). McClure et al. (16) reported that lambs fed concentrate had higher final live weights, carcass weights, and conformation scores than lambs fed forage. This is in contrast to the present trial, in which CCW and conformation scores did not differ between the 2 diet groups, although FLW was greater in the lambs fed concentrate. This may have been due to the differences in KO proportion between the 2 groups. The CONC group had a lower KO proportion than the SIL group, probably because of their higher gut fill. Lambs fed the concentrate diet consumed more energy and protein compared to lambs on the silage diet, which led to a higher growth rate and lower FCR in the lambs fed the concentrate diet. Significant interactions between breed and diet for growth and FCR may have been caused by the greater growth potential of S × M lambs, and differences in the energy and protein density of the CONC and SIL diets.

Finishing period and age at slaughter were adjusted using SFE as a covariate, as suggested by Wolf and Smith (17), so that comparison made at constant "finish" may approximate "constant degree of mature size". Taking estimates of mature live weight from the study of Croston and Pollott (18), S × M lambs (86 kg mature weight) and SBF lambs (70 kg mature weight) in the present study were approximately 55% and 57% of their mature weight, respectively, when slaughtered at the same level of fatness (SFE 11.75%). The S × M lambs finished 14 days earlier and were younger (7 days) at slaughter than the SBF lambs. The results of this trial are in agreement with the results of McClelland et al. (19) who compared a wide range of breeds (Soay, Southdown, Finnish Landrace, and Oxford Down) and found that age at slaughter did not depend on the mature weight of the lambs at the same stage of maturity when they were from very diverse backgrounds. However, Wolf et al. (9) and Kempster et al. (20) compared the age at slaughter between breeds with different mature weights and found that breeds of higher mature weights tended to take more time to reach slaughter at a constant fatness. These findings may in part be due to the differences in the type of breeds used. The lambs used in their studies were mostly from sire breeds, but in the present trial 2 different types of breeds were used (S × M: meat type; SBF: hill breed).

Lambs in the CONC group finished 58 days earlier than those in the SIL group and also were younger (162 days) at slaughter than those in the SIL group (220 days). This is in agreement with the results of previous studies (16,21). Differences in DLWG due to breed and diet led to differences in the number of days required to finish the lambs. The early finishing lambs in the CONC group had the highest daily weight gain, which is in agreement with the results of previous studies (11,12,14). Forage-based production systems may offer the option of reduced daily production costs, but may lead to increasing the number of days required to finish the animals (22). These differences in DLWG are presumably due to differences in mature live weight of the 2 breeds, and energy and protein density of feed consumed, and hence, total energy intake.

Significant breed and diet interactions indicated that S × M and SBF lambs responded differently to the CONC and SIL diets, in terms of KKCF and subcutaneous fat deposition over the eye muscle. Priolo et al. (8) and Saatci et al. (23) found that forage-fed lambs have less KKCF than concentrate-fed lambs. Anderson (24) found that concentrate-fed lambs had the least KKCF, although they were the youngest at slaughter. Povey (25) found that the carcasses of lambs fed silage alone had less KKCF than the carcasses of supplemented lambs. The different responses of the 2 breeds fed the CONC and SIL diets, in terms of KKCF and SFD, could be attributed to their different growth rates and age at slaughter. This might also be explained in light of a breed × diet interaction affecting FCR.

There was no significant difference between the eye muscle area of the lambs fed the CONC and SIL diets. This is in agreement with the findings of Povey (25) and Tariq (26), but is in contrast to the findings of McClure et al. (16) and Anderson (24) who found differences in the eye muscle area of lambs fed diets with different energy levels. The S × M lambs had significantly larger eye muscle area than SBF lambs, which is in accordance with the findings of Binnie et al. (27), but different than those of Lloyd et al. (28). However, our eye muscle area findings are in general agreement with the results of Kemp et al. (29) who found that eye muscle area increased with body weight. In addition, a strong positive association exists between conformation and eye muscle area, as reported by Crouse et al. (30). In the present trial S × M lambs had better conformation and larger eye muscle area than the SBF lambs.

It was concluded that finishing S × M lambs on the CONC diet was advantageous due to their higher lean content and lower fat content, in addition to being economical, as they finished 58 days earlier than lambs fed the SIL diet.

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