THE EFFECT OF QUALITY OF DIET ON FEED INTAKE, FEED DIGESTIBILITY, AND GROWTH RATE OF LAMBS IN AMBIENT TEMPERATURES OF 20 °C AND 30 °C

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ABSTRACT

A study has been made on the effect of feed quality on feed intake and live-weight gain in lambs housed at different ambient temperature. Sixteen Border Leicester x Merino whether lambs aged 7 months and weighing 33±1.5kg were allocated to a 2x2 factorial structure in a randomized block design. The factors were temperature (20 and 30°C) and diet (diet 1 contained low protein and high fibre, and diet 2 contained high protein and low fibre). Respiration rate (RR), rectal temperature (RT), feed intake, digestibility, live weight gain (LWG) and feed conversion ratio (FCR) were estimated. On both diets, lambs held at 20 °C had lower RT, higher intake, higher LWG and lower FCR than those at 30 °C. Lambs given diet 2 had higher feed intake, higher feed digestibility, higher LWG and thus lower FCR than those given diet 1. There was no significant difference in RT between diets. Temperature did not affect feed digestibility. There were significant interactions between temperature and diet for N intake and RR but not for other indices of lamb's performance. Lambs housed at 30°C were selecting feed with higher N content than that offered. At 20 °C, the lambs given diet 2 had a very significantly lower RR than that those given diet 1. However, the difference was, although still significant, mush less pronounced at 30 °C.

Key words: Lamb, Heat stress, Feed intake, Feed digestibility, Growth rate

INTRODUCTION

When heat stressed, ruminants attempt to reduce their metabolic heat production by reducing feed intake (Hafez, 1968; Conrad, 1985). They also attempt to enhance its heat dissipation by allowing its body temperature to rise, which increases the rate of heat loss by both sensible and evaporative means (Blaxter, 1962). When respiration rate rises, metabolic rate is likely to increase through protein oxidation (Blaxter, 1962), which Leng (1990) argues may increase the protein requirement per unit energy content in the diet. Together, these influences could result in a reduction in growth rate and/or, since a reduction in protein intake is associated with a reduction in the amount of amino acids digested and absorbed, and thus available for protein synthesis, an increase in the fat content of the body.

An experiment by Bhattacharya and Hussain (1974) showed that there was an interaction between ambient temperature and crude fibre content of the diet on feed intake of animals; during heat stress depression of feed intake and energy utilization was more pronounced in animals fed high-roughage diets than in these fed low-roughage diets. It has been largely accepted that fibrous diets produce more heat increment from the gut than concentrate-based diets of similar ME contents (Kellner, 1926; Tyller, 1975; Ørskov and MacLeod, 1990).

Despite the knowledge of dietary N requirement by animal at high temperature, there is no such research on eating behavior

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of lambs in responding heat stress. The current experiment was carried out to determine the effects of ambient temperature and feed quality on feed intake and digestion, and growth rate of lambs and lamb's selectivity for dietary N content. Two diets were formulated to provide equal digestible energy (DE) contents, one 'high' in protein and 'low' in fibre (diet 1), and the second 'low' in protein and 'high' in fibre (diet 2). The hypothesis proposed was that there would be an interaction between the effects of ambient temperature and type of diet (protein and fibre content) on the feed intake, feed digestibility and growth rate of lambs, with relatively better performance on the high protein/low fibre diet at high temperature.

MATERIALS AND METHODS

Animals and housing.

Sixteen Border Leicester x Merino wether lambs (aged 7 months and weighing 33.0±1.49 kg) were randomly allocated to treatments by stratified randomization on the basis of their intake of lucerne chaff during a 2-week pre-experimental period at 25 °C. The lambs were penned, fed and watered individually in two air-conditioned climate rooms, in both of which relative humidity was 70%, and lighting was continuous. Water, which was at ambient temperature, was freely available

Design.

A 2 x 2 factorial structure was used in a randomized block design for 10 weeks, after the 2-week pre-experimental period. The lambs were given one of two diet *ad libitum* (30% excess) at each of 2 ambient temperature: 20°C and 30 °C (continuous). Diet 1 consisted of a mixture of 50% lucerne chaff and 50% oaten chaff, while diet 2 consisted of 75% of commercial lambs pellet (Fielders, Tamworth, N.S.W., Australia, containing 60% lucerne meal, 19.40% sorghum, 20.25 millrun, and 0.35% minerals mix) and 25% lupin grain. The diets were formulated to have similar DE contents.

Procedures.

Weighed quantities were offered twice a day in order to ensure that adequate fresh feed was available to the lambs at all times. Feed refusals were collected twice a week. The feed intake was calculated from the difference between feed offered and feed refused. Samples of the feed offered and refused were collected for analysis.

Digestibility measurements, involving total fecal collections, were carried out over 5 successive days in week 6. Three of the 4 lambs in each temperature and diet treatment group were chosen to span the range in voluntary feed intakes of lambs in each treatment group.

The lambs were weighed every week to enable their live weight change to be determined. The parameters of productivity measured were live-weight gain (LWG, g/d) and feed conversion ratio (FCR), which was calculated from the amount of feed dry matter ingested per weight unit LWG (g/g).

The respiration rates (RR; timed flank movements) and rectal temperatures (RT; clinical thermometer inserted 10 cm for 2 min) of the lambs were measured once per week (at 14.00 h) as an indicator of the heat stress resulting from the higher ambient temperature.

Sample processing and analysis.

Representative sub sample of feed offered to and refused by the animals, and the feces from the animals were analyzed for dry matter (DM), organic matter (OM), nitrogen (N), gross energy (GE), acid detergent fibre (ADF), and lignin by procedures of AOAC.

Dry matter content was determined by heating the sub sample in the oven at temperature of 100 °C for 24 h. OM content was determined by ashing the sub sample in the furnace at 600°C for 8 hours. GE content was measured by bomb calorimeter. DE content was determined by digestibility measurement. Apparent DEI was calculated from the difference between GE intake and GE feces. Metabolizable energy content was estimated from digestible energy content timed by 0.81 (ARC, 1980; MAFF, 1984; SCA, 1990).

Table 1. The dry matter (DM), gross energy (GE), and nutrient content of the diets given to lambs

Feed	Diet 1 (high fibre, low N)	Diet 2 (low fibre, high N)
DM (g/100g feed as fed)	87.5	89.5
OM (g/100g DM	90.4	93.3
N (g/ 100g DM)	2.4	3.2
GE (MJ/kg)	20.8	19.2
ADF (g/ 100g DM)	32.8	21.9
Lignin (g/ 100g DM)	4.9	2.7
ME (MJ/kg)	11.2	11.6

Nitrogen content was determined by an organic determinator made by Leco Instrument (USA). ADF and lignin contents were determined the methods described by Van Soest (1963).

Statistical analysis.

The data collected were analyzed by analysis of covariance associated with 2 single treatment factors (temperature and diet), the covariate factor (initial feed intake), and interaction between temperature and diet.

RESULTS

Both diets had similar ME content, but diet 1 contained less N and more ADF and lignin than diet 2. The nutritional compositions of the diets given to the lambs are given in Table 1.For most indices of production, there were no significant interactions between the temperature and diet effects (P>.05), and therefore only main them treatment effects are presented (Table 2). Significant temperature x diet interactions were detected only for RR (P<.05, Table 3) and N intake (P<.05; Tables 3). Both DM and OM intakes differed between temperatures (P<.01) and between diets (P<.01), being higher for diet 2. For DE and ME intakes, the trends were similar, but only the difference between diets was significant (P<.05). N intake of lambs on diet 1 did not differ between temperatures, but N intake of lambs on diet 2 was significantly lower (P<.01) at 30 ^{o}C than at 20 ^{o}C. Apparent digestibility of diet 2 was higher than for diet 1 for DM (P<.05), OM (P<.01), energy (P<.05) and nitrogen (P<.01). Ambient temperatures had no significant effect on apparent digestibility (P>.05).

At 20 ^{o}C the lambs grew faster (P<.01) than at 30 ^{o}C, and the lambs given diet 2 grew faster (P<.01) than those given diet 1. FCR (g DMI/g LWG) did not differ (P>.05) between ambient temperatures. However, the FCR of lambs on diet 2 was lower (P<.001) than that on diet 1.

At 20 ^{o}C the difference in RR between diets was more pronounced than at 30 ^{o}C. At 30 ^{o}C RT was higher (P<.01) than at 20 ^{o}C, but RT did not differ between diets.

DISCUSSION

The showing higher DMI of diet 2 compared with diet 1 was in agreement with other workers who have generally found that low fibre diets with higher nitrogen content had higher intake while diets with higher ADF and lignin had lower intake (Forbes, 1970; Van Soest, 1982; McDonald *et al*, 1988; Ørskov and MacLeod, 1990).

When the forage supply is unlimited, voluntary feed intake (VFI) is limited by both rumen capacity and the rate of physical degradation of larger feed particle to smaller particles in the rumen and the rate of removal of small particles from the rumen. Rumen capacity is limited both by its size and its ability to stretch (Forbes, 1970). The rate of physical degradation of indigestible particulate matter largely explains the rate of

Table 2. The effects of ambient temperature and diet on feed intake, feed digestibility, lambs growth rate and feed conversion ratio

	Ambient Temperature		Diet		s.e.m	Effects[a]
	20 °C	30 °C	Diet 1	Diet 2		
RT (°C)	39.6	40.2	39.8	40.0	0.11	T**
Intake						
DM (g/d)	1213	1037	1050	1200	30	T**, D**
OM (g/d)	1116	952	948	1120	28	T**, D**
DE (MJ/d)	16.7	14.7	14.5	16.9	0.6	D*
ME (MJ/d)	13.5	11.9	11.7	13.7	0.5	D*
Digestibility (%)						
DM	66.7	68.3	60.3	74.6	2.3	D**
OM	66.8	68.5	60.6	74.7	2.0	D**
N(true)[b]	79.0	78.3	71.7	85.7	1.7	D**
Energy	69.7	70.7	66.1	74.5	1.8	D*
LWG (g/d)	154	114	78	190	8.0	T**, D**
FCR (g DMI/g LWG)	7.9	9.1	13.5	6.3	0.9	T*, D**

[a] T = temperature effect, D = diet effect, TxD = temperature x diet interaction

[b] Allowance made for Metabolic Fecal Nitrogen excretion: 0.036g N/kg $W^{0.75}$(SCA, 1990)

* P <.05

** P<.01

Legends: RR = respiration rate; RT = rectal temperature; DM = dry matter; OM = organic matter; DE = digestible energy; N = nitrogen; LWG = live weight gain; FCR = feed conversion ratio

passage of digests from the rumen, with a slow rate of particle size reduction being the major factor limiting the VFI of poor quality forages (Van Soest, 1982). Roughage diets, which usually contain relatively high concentrations of ADF and lignin, have a lower digestibility than diets containing lower concentrations of these fractions. Encapsulation of potentially digestible nutrients by lignin prevents both microbial digestion in the rumen and enzymatic digestion in the lower digestive tract, and contributes to the lower overall digestibility of such diets (McDonald *et al.*, 1988). This results in a low fractional passage rate of the digests and, in turn, a lowered VFI.

Ruminal microbial activity is determined in part by the supply of dietary N for the microbes, which can be RDP and/or NPN. Efficient degradation of the potentially digestible carbohydrate fraction can only occur if there is an adequate concentration of NH_3 at all times, Ammonia concentration can be maintained either by a protein source that is degraded slowly and releases NH_3 into the rumen over a long period of time, or by frequent feeding of rapidly degraded N sources (McAllan *et al*, 1982).

The significant interaction observed between temperature and diet on N intake can be attributed in part to diet selection, as illustrated by the fact that while the N contents of diet 1 and 2 were 2.4 and 3.2 % respectively (see Table 1), the N contents of the refusals of diet 1 were 1.9 and 1.7 % at 20 °C and 30 °C, respectively, while for the refusals of diet 2 the corresponding values were 3.1 and 3.0 % at 20 °C and 30 °C, respectively. These data indicate that the composition of food consumed differed between treatments, with lambs at 30 °C

Table 3. The effect of ambient temperature and diet on the respiration rate and Nitrogen intake of lambs*)

	RR (breaths/min)	N Intake (g/d)
20 °C		
Diet 1	147^{ab}	26.1^{ab}
Diet 2	116^{cd}	51.9^{cd}
30 °C		
Diet 1	172^{ef}	24.3^{ab}
Diet 2	168^{fg}	42.8^{fg}
s.e.m.	5.0	1.3

Figures with 1different superscript are significantly different (P<.05), and those with 2 different superscripts are highly significantly different (P<.01)

being more selective for N than those at 20 °C. The selection for dietary N was increased when the lambs were fed diet 1 (lower N content) compared to diet 2 (higher N content). Leng (1990) speculated that ruminants under tropical condition need higher P:E ratio in their feed. Thus it may be concluded that, while lambs in 30 °C had depressed feed intake, they attempted to fulfill they protein requirement by selecting feed with a higher N content.

The digestibility values recorded in the present experiment were in agreement with previous studies which have shown that, in general, the higher the dietary protein contents, the higher the digestibility, and the higher the fibre content the lower the digestibility (Thomas *et al*, 1980; Steen *et al*, 1989). The GE content of diet 1 was higher than that of diet 2 but the digestibility of energy of diet 2 was higher than that of diet 1, resulting in a non-significant difference in DE content between diet 1 and diet 2, ie. 13.8 MJ/kg and 14.3 MJ/kg respectively (see Table 2).

The lack of any significant differences in digestibility between ambient temperatures in the current experiment suggests that the increase in temperature imposed, from 20 to 30 °C, which led to a reduction in feed intake of only 14%, was not large sufficient to alter MRT of the digests in the digestive tract appreciably. Another possible explanation for lack of difference in digestibility is that the MRT of the digests at 20 °C was already long enough to provide maximum digestion, so that prolongation of MRT which occurs as a result of high ambient temperature (Blaxter, 1962; Moose *et al*; 1969; Attebery and Johnson, 1969; Warren *et al*, 1974; Koes and Pfander; 1975), did not further increase digestibility.

The lambs held at the lower temperature had higher live weight gains than did those at higher temperature. This outcome is in agreement with the results of Moose *et al* (1969), and is consistent with the higher digestible energy intake and the higher P:E ratio in the feed ingested, at the lower temperature.

The lower FCR of lambs housed at 20 °C than those at 30 °C, and the lower FCR of diet 2 compared to diet 1, can be largely attributed differences in LWG; since although significant, the differences in DMI were relatively small. It indicates that the lambs at 30 °C need more energy for combating heat stress, so that the energy left for production was smaller than those at 20°C.

Despite the lower DMI, lambs fed diet 1 had higher RR than lambs fed diet 2. This indicates that diet 1 caused higher heat increment, so that the lambs had to dissipate more body heat into the environment. The heat increment of feeds differs from one to another and depends on the nature of the feed (Blaxter, 1962; McDonald *et al*, 1988; Ørskov and MacLeod, 1990). Ørskov and Mac Leod (1990), calculated that, at the same ME intake (60 MJ/d), heat production in steers of a high-roughage diet was 10% higher than that of a concentrate diet.

The RR of the Border Leicester x Merino lambs at 20 °C in this experiment was high relative to RR in other studies. A study of Suffolk lambs by Bunting *et al* (1992), for example, showed that at 21 °C the RR averaged only 51 breaths/min, as compared to a mean of 131 breaths/min in this experiment. The higher RR here can attributed to differences in breed, and the fact that Bunting's lambs were fed at a maintenance level while the present ones which were fed *ad libitum*, consumed about 2.7 times maintenance (SCA, 1990).

The increases in RR and RT, together with depressed feed intake, observed at 30°C suggest that the lambs were moderately heat stressed. During heat stress animals attempt to dissipate additional body heat by evaporative cooling, through panting and allowing their body temperature to increase (Blaxter, 1962; Bianca, 1968), and decrease heat production by reducing feed intake (Moose *et al*, 1969; Bhattacharya and Hussain, 1974; Bhattacharya and Uwayjan, 1975).

CONCLUSION

The effects on lambs growth and FCR of protein and fibre levels in the diet were consistent at both 20 °C and 30 °C (there was no interaction between diet and temperature). Lambs fed the higher protein, lower fibre diet had higher growth rate and more efficient feed conversion than those fed the low protein, high fibre diet. Lambs held at 20 °C gained weight more rapidly than those housed at 30 °C.

While lambs housed at 30 °C had 14% lower feed intake, they consumed a relatively high amount of N and apparently attempted to fulfill their protein requirement. Lambs at 30 °C were more selective for material with higher dietary N content than those at 20 °C. The selectivity was increased when the diets were lower in N content.

ACKNOWLEDGEMENT

The authors thank to Mr. N.D. Baillie for technical assistance during the experiment, and to Associate Professor C.J. Thwaites for the helpful discussions during the preparation of this paper.

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