THE EFFECT OF QUALITY OF DIET ON CARCASS AND MEAT CHARACTERISTICS OF LAMBS AT AMBIENT TEMPERATURES OF 20 AND 30°C

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ABSTRACT

An experiment to investigate the effects of diet and ambient temperature on carcass and meat characteristics were carried out using 16 Border Leicester x Merino wether lambs, aged 7 months and weighing 33.0±1.49 kg. The weathers were randomly allocated to a 2 x 2 factorial structure of treatments in a randomized block design. The treatments were 2 different ambient temperatures (20° and 30°C) and 2 different diets (LPHF, high fibre and low protein; HPLF, low fibre and high protein). Diet HPLF resulted in a higher dressing percentage and back-fat thickness than diet LPHF (49.7 *vs* 44.4 % and 14.2 *vs* 6.8 mm respectively), but there was no effect of temperature on carcass characteristics. There was a significant interaction between temperature and diet on eye muscle area. For lambs fed LPHF, eye muscle area was smaller at 30°C than at 20°C, whereas for lambs fed HPLF, temperature had no significant effect. The meat from lambs fed HPLF was tastier, as assessed by a taste panel, than that from those fed LPHF, but there was no significant effect of temperature on meat flavour. There were no significant effects of either temperature or diet on the pH, colour or tenderness of the meat.

(Key words: Lambs, Heat stress, Diet, Carcass, and Meat).

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PENGARUH KUALITAS RANSUM DNA TEMPERATUR LINGKUNGAN TERHADAP KARAKTERISTIK KARKAS DAN DAGING DOMBA

INTISARI

Penelitian untuk mengetahui pengaruh ransum dan suhu lingkungan terhadap karakteristik karkas dan daging telah dilakukan dengan menggunakan 16 ekor domba persilangan Border Leicester x Merino jantan kastrasi, umur 7 bulan, bobot 33.0±1.49 kg. Domba-bomba tersebut dialokasikan secara acak pada perlakuan dalam rancangan acak kelompok dengan struktur faktorial 2 x 2. Perlakuan yang diterapkan adalah suhu lingkungan (20° and 30°C) dan ransum (RPTS: rendah protein tinggi serat, dan TPRS: tinggi protein rendah serat). Ransum TPRS memberikan hasil persentase karkas dan ketebalan lemak punggung yang lebih tinggi daripada ransum RPTS (49.7 *vs* 44.4 % dan 14.2 *vs* 6.8 mm berturutan), tetapi tidak terdapat pengaruh nyata suhu terhadap karakteristik karkas. Terdapat interaksi nyata antara suhu dan ransum pada otot mata rusuk. Pada domba yang mendapat ransum RPTS, suhu berpengaruh nyata, sementara pada domba yang mendapat TPRS, suhu tidak berpengaruh nyata. Daging domba yang diberi RPTS mempunyai rasa yang lebih enak daripada domba yang dib..i TPRS. Suhu tidak berpengaruh nyata terhadap aroma daging. Baik suhu maupun ransum tidak berpengaruh nyata pada pH, warna maupun keempukan daging.

(Kata kunci: Domba jantan kastrasi, Cekaman panas, Karkas, Daging).

Introduction

When heat stressed, ruminants attempt to reduce their metabolic heat production by reducing feed intake (FI) (Hafez, 1968; Conrad, 1985). During heat stress, metabolic rate is likely to increase through Q_{10} effects and increased protein oxidation (Graham *et al.*, 1959), which may increase the protein requirement per unit energy content in the diet (Leng , 1990). These influences are likely to result in a reduction in liveweight gain and/or an increase in the proportion of fat in the body.

An experiment by Bhattacharya and Hussain (1974) showed that with respect to FI there was an interaction between ambient temperature and the crude fibre content of the diet; for animals at high ambient temperature the reductions in feed intake and energy utilization were more severe when high-roughage rather than low-roughage diets were fed. It has been largely accepted that fibrous diets produce a larger HI from the gut than concentrate-based diets of similar metabolisable energy (ME) content (Ørskov and McLeod, 1990).

This experiment was carried out to determine the effects of ambient temperature and feed quality (protein and fibre contents) on FI, digestion, liveweight gain (LWG) and carcass characteristics and meat characteristics of lambs. Some of the results, i.e. FI, digestibility and LWG have been reported previously (Rianto *et al.*, 1998). The results being reported here are focused on carcass and meat characteristics. The hypothesis proposed was that carcass weight, dressing percentage and back-fat thickness would be higher for the lambs fed diet containing high protein low fibre (HPLF) than for that containing low protein high fibre (LPHF), and at 20°C rather than 30°C, and the meat characteristics of lambs fed HPLF are better than LPHF.

Materials and Methods

Animals and experimental design

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.

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 (LPHF) consisted of a mixture of 50% lucerne chaff and 50% oaten chaff, while diet 2 (HPLF) consisted of 75% of commercial lamb 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.

Procedures

The procedures in providing feed have been described in the previous report (Rianto *et al.*, 1998), i.e. weighed quantities of feed 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.

After 74 days feeding period (day 88 overall including pre-experimental period), all 16 lambs were slaughtered and carcasses were stored for 24 h at 4°C and then at -20°C for 2 months. The carcasses were then individually halved, while frozen, by sawing along the centre of the spinal column and the following measurements made on the right side of each carcass: eye muscle area, subcutaneous fat thickness, loin muscle colour, pH and tenderness.

Eye muscle area (cm^2) was measured between the 10^{th} and 11^{th} ribs by means of a compensating planimeter from a tracing made on transparent plastic. Subcutaneous back-fat thickness (mm) was measured over the centre of the *longissimus dorsi* muscle between the 10^{th} and 11^{th} ribs.

The loin colour on a freshly cut surface of the *longissimus dorsi* was measured by a Colourimeter (Minolta; Japan). The colour parameters measured were lightness (L), green-red colour range (a) ,and blue-yellow colour range (b). The loin pH was measured by a meat pH-meter; colour and pH measurements were carried out on thawed raw meat.

Table 1. The Nutrient contents of the diets used and the nitrogen contents of the corresponding feed refusals at 20° and 30°c

Diet	DM (%)	OM (%)	N (%)	ADF (%)	Lignin (%)
LPHF†	87.5	90.4	2.3	32.8	4.9
Lucerne chaff (50 %)	86.0	89.7	3.3	28.3	4.9
Oaten chaff (50 %)	89.0	91.1	1.4	37.3	4.9
HPLF	89.5	93.3	3.2	21.9	2.7
Pellets (75 %)	88.0	92.2	2.7	21.3	3.4
Lupins (25 %)	91.0	96.6	4.9	20.9	0.6

† LPHF = low protein high fibre; HPLF = high protein low fibre; DM = dry matter; OM = organic matter; GE = gross energy; N = nitrogen; ADF = acid detergent fibre
All measurements in all Tables are expressed on a DM basis

The tenderness of the *logissimus dorsi* at the loin position (between lumbar vertebrae 3 and 10) was measured on cooked, trimmed meat by objective test and by a taste panel consisting of 20 trained members. To this end, about 180 g of each loin was cooked in water of 80°C for 50 min. The Warner-Bratzler shear and compression measurements (Lloyd Instruments; U.K.) were used for objective tests for tenderness, and the taste panel test was for tenderness and flavour; the score range used by the taste panel for tenderness was: 1) Extremely tough, 2) Very tough, 3) Slightly tough, 4) Slightly tender, 5) Very tender, and 6) Extremely tender. For flavour the range was: 1) Extremely tasteless, 2) Very tasteless, 3) Slightly tasteless, 4) Slightly tasty, 5) Very tasty, and 6) Extremely tasty.

Statistical analysis

The data were analyzed by analysis of variance. The sources of variance were 2 single treatment factors (temperature and diet), and the interaction between them.

Results

Carcass characteristics

The effects of treatments on carcass characteristics are presented in Table 2, there being no significant ($P>0.05$) interactions. Carcass weight was significantly influenced by both temperature ($P<0.05$) and diet ($P<0.001$). The lambs at 20°C had heavier carcasses than those at 30°C, and the lambs fed diet HPLF had heavier carcasses than those fed diet LPHF. There was also a significant ($P<0.001$) difference in dressing percentage between diets (49.7 % for HPLF; 44.4 % for LPHF), but not between temperatures ($P>0.05$; Table 2).

There was no significant interaction between temperature and diet on the thickness of back-fat. While there was no significant difference in back-fat thickness between temperatures, however there was a significant difference ($P<0.001$) between diets, with lambs fed the HPLF diet recording higher values than those fed LPHF (Table 2).

There was a significant interaction between temperature and diet on eye muscle area ($P<0.05$). When the lambs were fed diet LPHF, eye muscle area was significantly less at 30°C than at 20°C ($P<0.01$), whereas when the lambs were fed diet HPLF, eye muscle areas were similar at both temperatures (see Table 3).

Table 2. The effects of temperature and diet on the carcass weight, dressing percentage and back-fat thickness of lambs

Parameter	Ambient temperature		Diet		s.e.m	Effects[††]
	20°C	30°C	LPHF[†]	HPLF		
LWG (g/d)	154	114	78	190	8.0	T**, D**
Carcass Weight (kg)	21.3	19.3	17.3	23.3	0.51	T*, D**
Dressing Percentage	47.4	46.7	44.4	49.7	0.68	D***
Back-fat thickness (mm)	11.0	10.0	6.8	14.2	0.94	D***

[†]LPHF = low protein high fibre; HPLF = high protein low fibre

[††] T= temperature; D = diet; * = $P < 0.05$; ** = $P<0.01$; *** = $P<0.001$

Table 3. The effects of temperature and diet on the eye muscle area ($Cm^2 \pm$ s.e.) of lambs

Diet	Ambient temperature	
	20°C	30°C
LPHF†	12.9±0.45a††	10.5±0.45b
HPLF	13.0±0.45a	12.9±0.45a

†LPHF = low protein high fibre; HPLF = high protein low fibre
†† Values with different superscripts are significantly different (P<0.01)

Table 4. The effects of temperature and diet on the meat characteristics (Loin Eye Muscle) of Lambs

Parameter	Ambient temperature		Diet		s.e.m.	Effects††
	20°C	30°C	LPHF†	HPLF		
PH	5.6	5.5	5.6	5.5	0.24	
Colour range						
L (lightness)	36.8	36.1	36.7	36.2	0.77	
a (green-red)	20.7	20.9	20.8	20.8	0.57	
b (blue-yellow)	11.0	10.9	10.8	11.1	0.44	
Tenderness						
• Objective Test						
Warner Bratzler (kg)	5.5	5.4	5.5	5.4	0.24	
Compression (kg)	2.7	3.3	3.0	3.0	0.23	
• Panel Test	4.3	4.4	4.1	4.6	0.18	
Flavour (Panel score)	3.6	3.3	3.1	3.8	0.17	D*

†LPHF = low protein high fibre; HPLF = high protein high fibre
††D = diet; * = P < 0.05

Meat characteristics

There were no significant interactions between temperature and diet with respect to any of the meat characteristics measured, the treatment means of which are presented in Table 4. Except for a significant preference shown by the taste panel for the flavour of meat from lambs fed diet HPLF (P<0.05), there were no significant differences between temperatures, or between diets in any of the meat characteristics measured (Table 4).

Discussion

The present results showing that both ambient temperature and diet affected carcass weight and that both temperature and diet affected back-fat depth are in agreement with other studies (see, for example, the studies of Fahmy *et al.*, 1992; Chestnutt, 1994). Chestnutt (1994) fed lambs at from *ad libitum* to 50 % of *ad libitum* FI and found that the effects of carcass weight on back-fat thickness and a number of other indices of fatness were greater on the high plane of feeding than on a low one. In view of the carcass results discussed above, the hypothesis proposed can be accepted in part only. That is, that carcass weight, dressing percentage and back-fat thickness were higher for HPLF than for LPHF. However, for the temperature effect, only the differences in carcass weight supported the hypothesis.

The significant difference between diets in meat flavour recorded in this experiment is in agreement with other studies (Cramer *et al.*, 1967; Park *et al.*, 1972a & b; Shorland *et al.*, 1970; Summers *et al.*, 1978; Crouse *et al.*, 1981). For example, Cramer *et al.*, (1967) fed lambs on white clover (*Trifolium repens*) or perennial ryegrass (*Lolium perenne*) and found that white clover led to a stronger flavour than perennial ryegrass. The current result was, however, unexpected. The largest single constituent of diets LPHF and HPLF was lucerne chaff, but the other major constituents varied (oaten chaff for LPHF; sorghum and lupins for HPLF) so that it is not possible to attribute the flavour difference to a specific factor (e.g. protein of crude fibre) or dietary constituent. Another possible contributor to the flavour difference observed is the level of carcass fatness. Carcasses from lambs fed HPLF were fatter than their LPHF counterparts, and Cramer *et al.*, (1967) have shown that meat flavour is derived from both fat and lean tissues. Though the flavour differences in this 1 were significant ($P<0.05$), from a practical viewpoint of consumer acceptance of the meat it should be noted that the mean LPHF and HPLF scores of 3.1 and 3.8 respectively fell between the 'slightly tasteless' and 'slightly tasty' categories. That is, in the current experiment, the flavour of meat from both diets failed to be rated highly.

Conclusions

From this experiment it could be concluded that carcass weight, dressing percentage and back-fat thickness were higher for lambs fed the HPLF diet, but that temperature had a significant effect only on carcass weight (higher at 20°C than at 30°C). For the meat characteristics studied, only the effect of diet on meat flavour as assessed by a taste panel was significant, but both meats failed to score highly for flavour.

References

Arnold, G. W. 1964. Some principles in the investigation of selective grazing. Proc. Aust. Soc. Anim. Prod. 5: 258-271.

Attebery, J. T. and H. D. Johnson. 1969. Effects of environmental temperature, controlled feeding and fasting on rumen motility. J. Anim. Sci. 29: 734-737.

Bhattacharya, A. N. and F. Hussain. 1974. Intake and utilization of nutrients in sheep fed different levels of roughage under heat stress. J. Anim. Sci. 38: 877-886.

Bhattacharya, A. N. and M. Uwayjan. 1975. Effect of high ambient temperature and low humidity on nutrient utilization and on some physiological responses in Awasi sheep fed different levels of roughage. J. Anim. Sci. 40: 320-328.

Bianca, W. 1968. Thermoregulation. In Adaptation of Domestic Animals, pp. 97-118 (E.S.E. Hafez, Ed.). Lea and Febiger, Philadelphia.

Blaxter, K. L. 1962. The Energy Metabolism of Ruminants. Hutchinson, London.

Brown, G. D. 1971. Thermal status of sheep at pasture in western New South Wales. Aust. J. Agric. Res. 22: 797-808.

Bunting, L. D., L. S. Sticker, and P. J. Wozniak. 1992. Effect of ruminal escape protein and fat on nitrogen utilization in lambs exposed to elevated ambient temperatures. J. Anim. Sci. 70: 1518-1525.

Chestnutt, D. M. B. 1994. Effect of lamb growth rate and growth pattern on carcass fat levels. Anim. Prod. 58: 77-85.

Conrad, J. H. 1985. Feeding of farm animals in hot and cold environments. In Stress Physiology in Livestock: Vol. II. Ungulates, pp. 205-226 (M.K. Yousef, Ed.). CRC Press, Boca Raton.

Cramer, D. A., R. A. Barton, F. B. Shorland, and Z. Czochanska. 1967. A compari-

son of the effects of white clover (Trifolium repens) and of perennial ryegrass (Lolium perenne) on fat composition and flavour of lamb. J. agric. Sci., Camb. 69: 367-373.

Crouse, J. D., J. R. Busboom, R. A. Field, and C. L. Ferrell. 1981. The effects of breed, diet, sex, location and slaughter weight on lamb growth, carcass composition and meat flavor. J. Anim. Sci. 53: 376-386.

Fahmy, M. H., J. M. Baucher, L. M. Poste, R. Gregoire, G. Butler, and J. E. Comeau. 1992. Feed efficiency, carcass characteristics, and sensory quality of lambs, with or without prolific ancestry, fed diets with different protein supplements. J. Anim. Sci. 70: 1365-1374.

Graham, N. McC., F. W. Wainman, K. L. Blaxter, and D. G. Armstrong. 1959. Environmental temperature, energy metabolism and heat regulation in sheep. 1. Energy metabolism in closely clipped sheep. J. Agric. Sci., Camb. 52: 13-24.

Hafez, E. S. E. 1968. Environmental effects on animal productivity. In Adaptation of Domestic Animals, pp. 74-93 (E.S.E. Hafez, Ed.). Lea and Febiger, Philadelphia.

Hopkins, P. S., G. I. Knights, and A. S. Le Feuvre. 1978. Studies of the environmental physiology of tropical Merinos. Aust. J. agric. Res. 29: 161-171.

Johnson, K. G. 1971. Body temperature lability in sheep and goats during short-term exposures to heat and cold. J. agric. Sci., Camb. 77: 267-272.

Koes, R. M. and W. H. Pfander. 1975. Heat load and supplement effects on performance and nutrient utilization by lambs fed orchard-grass hay. J. Anim. Sci. 40: 313-319.

Leng, R. A. 1990. Factors affecting the utilization of 'poor quality' forages by ruminants particularly under tropical conditions. Nutr. Res. Rev. 3: 277-303.

McDonald, P., R. A. Edwards, and J. F. D. Greenhalgh. 1988. Animal Nutrition, 4th Ed. Longman Scientific and Technical, Harlow.

Moody, E. G., Van P. J. Soest, R. E. McDowell, and G. L. Ford. 1967. Effect of high temperature and dietary fat on performance of lactating cows. J. Dairy Sci. 50: 1909-1916.

Moose, M., C. V. Ross, and W. H. Pfander. 1969. Nutritional and environmental relationships with lambs. J. Anim. Sci. 29: 619-627.

Ørskov, E. R. and N. A. MacLeod. 1990. Dietary-induced thermogenesis and feed evaluation in ruminants. Proc. Nutr. Soc. 49: 227-237.

Park, R. J., J. L. Corbett, and E. P. Furnival. 1972a. Flavour differences in meat from lambs grazed on lucerne (Medicago sativa) or phalaris (Phalaris tuberosa) pastures. J. agric. Sci., Camb. 78: 47-52.

Park, R. J., R. A. Spurway, and J. L. Wheeler. 1972b. Flavour differences in meat from sheep grazed on pasture or with winter forage crops. J. Agric. Sci., Camb. 78: 53-56.

Rianto, E., M. K. Hill, and J. V. Nolan. 1998. The Effect of Quality of Diet on Feed Intake, Feed Digestibility, and Growth Rate of Lambs in Ambient Temperature of 20°d 30°C. Bul. Anim. Sci., Gajah Mada Univ. Supplement Edition: December 1998.

Shorland, F. B., Z. Czochanska, N. Noy, R. A. Barton, and A. L. Ray. 1970. Influence of pasture species on the flavor, odor and keeping quality of lamb and mutton. J. Sci. Food Agric. 21: 1-4.

Steen, R. W. J., E. F. Unsworth, H. I. Gracey, S. W. J.Kennedy, R. Anderson, and D. J. Kilpatrick. 1989. Evaluation studies in the development of a commercial bacterial inoculant as an additive for grass silage. 3. Responses in growing cattle and interaction with protein

supplementation. Grass and Forage Sci. 44: 381-390.

Summers, R. L., J. D. Kemp, D. G. Ely, and J. D. Fox. 1978. Effects of weaning, feeding system and sex of lamb on lamb carcass characteristics and palatability. J. Anim. Sci. 47: 622-629.

Thomas, C., M. Gill, and A. R. Austin. 1980. The effect of supplements of fish meal and lactic acid on voluntary intake of silage by calves. Grass and Forage Sci. 35: 275-279.

Warren, W. P., F. A. Martz, K. H. Asay, E. S. Hilderbrand, C. G. Payne, and J. R. Vogt. 1974. Digestibility and rate of passage by steers fed tall fescue, alfalfa and orchardgrass hay in 18 and 32 C ambient temperatures. J. Anim. Sci. 39: 93-96.