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Reduction of carcass fatness in overfat lambs fed low energy diets supplemented with protein

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ABSTRACT

Forty crossbred (Dorset Down x (Border Leicester x Romney)), overfat (ultrasonic GR 13.3 ± 0.5 mm), ewe lambs aged approximately 6 months and weighing 40.4 (±0.8) kg live weight were randomly allocated to either an initial slaughter group or one of three dietary treatment groups on the basis of live weight and ultrasonic GR measurement. Dietary treatments consisted of three pelleted diets that contained 101g (MP), 189g (HP) and 274g (SP) crude protein with estimated metabolizable energy contents ranging from 7.1 to 7.8 MJ per kg dry matter. Lambs were fed *ad libitum* for 42 days.

Throughout the experiment, daily live weight gain was significantly higher for MP than HP or SP lambs ($P<0.01$). However, this was solely due to greater gut fill for MP lambs compared to HP and SP lambs ($P<0.05$). There were no significant treatment effects on mean carcass weight. However, all treatments significantly ($P<0.05$) reduced GR tissue depth (measured on hot carcass at slaughter) by 20%, 19% and 24% for MP, HP and SP lambs, respectively. Chemical fat content in the carcass significantly decreased (8%, 12% and 16%, respectively ($P<0.05$)). Differences between dietary treatments were not significant for these traits. *M. longissimus dorsi* area and protein content of the carcass were not significantly altered by dietary treatments ($P>0.05$).

It is concluded that carcass fat in overfat lambs can be successfully reduced by feeding diets low in energy and supplemented with medium to high levels of protein without adverse effects on carcass protein. High levels of dietary protein do not appear to be necessary for this to occur.

Keywords: Lamb; overfat; energy; protein; carcass; fatness; lean; hot GR; ultrasonic GR.

INTRODUCTION

Studies into the reduction of carcass fatness for overfat lambs in New Zealand are of importance, since overfatness is a major revenue loss to sheep farmers and meat processors. Nutritional manipulation of carcass composition is a consumer acceptable method to reduce fatness as it does not involve physiological manipulation or animal stress.

Recent studies (Vipond *et al.*, 1989; Cruickshank *et al.*, 1992) suggest that feeding overfat lambs for a short period with low energy/ high protein diets can reduce carcass fatness while maintaining carcass protein. These studies were based on the finding by Hovell *et al.* (1983) that lambs fed entirely by intragastric infusion could maintain a positive nitrogen balance while being in a negative energy balance. Further work by Fattet *et al.* (1984) showed that lambs fed below maintenance on diets based on treated straw supplemented with 125 g/ day of fish-meal lost body fat while body protein increased. Subsequently, Vipond *et al.* (1989) and Cruickshank *et al.* (1992) applied this theory to the feeding of overfat lambs to reduce carcass fatness. While they did not observe protein gains in supplemented animals, protein losses were small compared to unsupplemented animals. Results from these studies do not allow the optimum level of protein supply to be defined.

This study was set up with the objective of reducing carcass fatness in overfat lambs while increasing or maintaining the meat content of the carcass. Treatments were selected to define the optimum level of protein to supply.

MATERIALS AND METHODS

Forty crossbred (Dorset Down x (Border Leicester x Romney)), overfat (ultrasonic GR 13.3 ± 0.5 mm), ewe lambs were bought from a commercial farm. They were approximately 6 months of age with an average live weight of 40.4 (±0.8) kg. Lambs were randomly allocated in a stratified manner, on the basis of live weight and ultrasonic GR, to an initial slaughter group or to one of three dietary treatment groups (n=10/group). Animals in the latter groups were kept indoors in individual pens for 42 days and then slaughtered.

Dietary treatments consisted of three pelleted diets for which the proportions of barley straw and fish meal varied. Ingredients of the diets are shown in Table 1. The diets were designated, medium-protein (MP), high-protein (HP) and super-protein (SP). All lambs were fed *ad libitum* (approximately 20% refusal) once daily for 42 days. Feed offered and feed refusals were weighed and sampled daily throughout the trial. Pooled materials were subsampled and analysed for dry matter and crude protein. Water was available at all times.

Lambs were weighed weekly after a 12 h fast, at the same time each week to minimise variation due to gut fill. Ultrasonic GR was recorded weekly (except for week 1) using an ALOKA SSD-210DXII ultrasound machine, approximately 11 cm from the midline over the 12th rib at the same anatomical position on each sheep.

Each lamb was shorn the day before slaughter. At slaughter the alimentary tract was removed, emptied and weighed. GR was measured on the hot carcass 11 cm from the midline over the 12th rib. The carcass was weighed hot, chilled for 24h

TABLE 1: Ingredients and composition of the medium-protein (MP), high-protein (HP) and super-protein (SP) pelleted diets.

Diets	MP	HP	SP
Ingredients (g/kg)			
Barley-straw	798	705	613
Fish-meal	120	213	305
palabind molasses	5.0	5.0	5.0
Bentonite	2.0	2.0	2.0
Masking agent	0.2	0.2	0.2
Vitamins and mineral	1.0	1.0	1.0
Composition			
Crude protein (g/kg DM)	101	189	274
Estimated ME (MJ/kg DM)[1]	7.08	7.46	7.84

[1]Calculated from food tables (Ulyatt *et al.*, 1980).

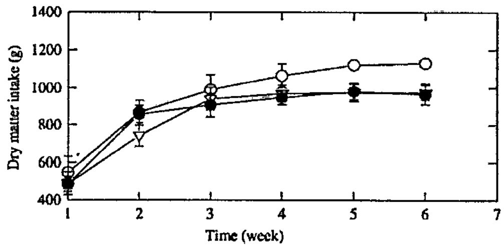
at 4°C, weighed again and then frozen. Subsequently the frozen carcass was split in half and the left side was cut horizontally along the cranial edge of the 12th rib. *M. longissimus dorsi* width (A) and depth (B) were measured on the cut surface. Muscle area was calculated as A x B x 0.8 (Hopkins, 1990). Fat depth (C site) was measured over the muscle at the position of maximum muscle depth (Wood & Macfie, 1980). After measurement half carcasses were minced, subsampled and chemically analysed for dry matter, protein, fat and ash.

Data were analysed using General Linear Model Procedures (SAS, 1990). Fleece-free empty body weight and carcass weight were used as covariates in analyses where appropriate.

RESULTS

Mean values for voluntary feed intake for lambs during the experimental period are shown in Figure 1 and Table 2. For all diets, intake was low initially (average of 350g DM per day for the first three days) but increased rapidly to an average of 854g DM per day by the second week and then increased slightly. DM intakes (g/ kg $LW^{0.75}$/ d) of MP lambs were significantly higher (P<0.01) than those on HP and SP diets. Energy intakes (KJ ME/ kg $LW^{0.75}$/ d) across treatments were not statistically different. Substantial differences in protein intake reflected diet composition of the three treatments.

FIGURE 1: Dry matter intake of overfat lambs fed MP (○), HP (●) and SP (∇) diets.



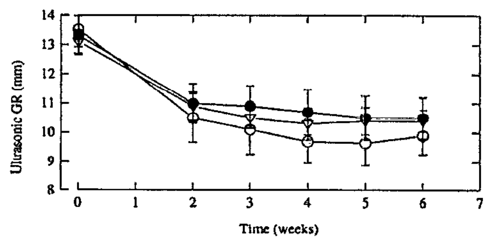
Changes in live weight for lambs during the treatment period are shown in Table 2. All lambs gained live weight. Daily live weight gain of MP lambs was greater than HP (P<0.05) and SP (P<0.001) lambs. However, MP lambs had greater gut fill which accounted for their greater live weight gain (Table 3). Ultrasonic GR declined in all groups (P<0.05; Figure 2 and Table 2), but no significant differences among the three treatments were apparent. The major change occurred during the first two weeks and thereafter slowly.

TABLE 2: Effect of diet on mean values for feed intake and changes in live weight and ultrasonic GR.

Variables	Slimming diets MP	HP	SP	Significance SED[2]	level
Dry matter Intake (g/kgLW$^{0.75}$per day)	58.4	52.5	50.0	4.1	**
Energy Intake (KJME/kgLW$^{0.75}$per day)	413	392	392	30.3	NS
Protein Intake (g/kg LW$^{0.75}$per day)	5.9	9.9	13.7	0.81	***
Live weight change (g/d)	137	85	45	25.6	***
Ultrasonic GR change (mm/d)	-0.09	-0.07	-0.06	0.02	NS

* P<0.05, ** P<0.01, *** P<0.001, NS non-significant.
[2] Standard error of difference between means.

FIGURE 2: Ultrasonic GR of overfat lambs fed MP (○), HP (●) and SP (∇) diets.



Carcass weight and carcass measurements for all slaughter groups are shown in Table 3. There were no significant differences in carcass weight between slaughter groups. However, GR decreased by an average of 21% in the dietary treatment groups (P<0.05). Backfat thickness (C site) measured over the *M. longissimus dorsi* also decreased (P<0.05). Differences between dietary treatments were not significant for these traits. *M. longissimus dorsi* depth, width and area were not significantly altered by dietary treatments.

Weights of chemical components of the carcass are shown in Table 3. All groups lost carcass fat (P<0.05) during the experimental period. There was a non-significant trend for the magnitude of this loss to increase as protein intake increased. In comparison, protein and water content of the carcass were not significantly affected by dietary treatment.

While liver weight was reduced in all groups, there was a positive relationship between mean liver weight and protein level in the diet (P<0.001).

DISCUSSION

Findings from the present study support the hypothesis that low energy, high protein diets will cause overfat lambs to mobilise fat whilst maintaining protein. However, the

TABLE 3: Slaughter measurements and carcass chemical composition for initial slaughter group and three dietary treatment groups.

Variables	Initial slaughter group	Final slaughter groups MP	HP	SP	SED[2]	Significant level
Non-carcass components						
Gut fill (kg)	3.0	10.4	8.5	7.1	0.5	***
Liver (g)	873	559	670	713	26.1	***
Carcass measurements						
Hot carcass weight (kg)	18.8	18.7	18.8	18.8	0.30	NS
Hot GR (mm)	14.2	11.4	11.5	10.8	1.57	*
Backfat thickness	(mm)	4.0	2.9	2.7	3.0	0.61*
M. longissimus dorsi						
Depth (mm)	29.5	29.8	29.7	28.8	1.5	NS
Width(mm)	55	56	54	54	1.9	NS
Area (cm2)	13.0	13.3	12.8	12.5	0.80	NS
Carcass chemical components						
Fat (kg)	5.83	5.35	5.14	4.92	0.34	*
Protein (kg)	3.46	3.44	3.36	3.46	0.17	NS
Water (kg)	8.89	8.82	8.82	8.88	0.21	NS

* $P<0.05$, ** $P<0.01$, *** $P<0.001$, NS non-significant.
[2] Standard error of difference between means.

simple effect of low energy intake cannot be ruled out.

Lambs were clearly below maintenance during the trial period, since body energy decreased as evidenced by change in fat weight (Table 3). An ARC (1980) estimate for maintenance in these animals (370 KJ/ kg $LW^{0.75}$/ d) underestimated the requirement for these sheep.

A trend for greater body fat loss to occur with higher dietary protein intake was not associated with an opposite trend for body protein as shown by Fattet *et al.* (1984). However, results were similar to those reported by Vipond *et al.* (1989) and Cruickshank *et al.* (1992). Vipond *et al.* (1989) found that while protein and fat were lost in unsupplemented lambs, feeding a protein supplement substantially reduced the loss of protein with negligible effect on fat loss. However these data cannot be readily compared to those of the present study given the lack of an initial slaughter group. Cruickshank *et al.* (1992) observed greater changes in carcass weight and GR than seen in the present study. Their data support the findings of Vipond *et al.* (1989) whereby fat losses in supplemented and unsupplemented lambs were similar, with smaller losses of carcass weight in protein supplemented animals. Significant treatment differences were found in these studies, but not in the present study. This may reflect treatment design. While the former studies looked at supplemented (with high protein) and unsupplemented lambs, the present study examined supplementation with medium to high levels of protein. Thus, the major effect of protein supplementation may be elimination of a low protein supply for young animals fed near maintenance.

Evidence that the "extra" protein was escaping rumen degradation and being absorbed is provided by the data for liver weight where decreases in liver weight were smaller as protein intake increased. This effect appeared to be due to protein absorption rather than energy absorption since estimated energy intakes were not different between treatments (Table 2). It may be that an energy deficit limited further gains in protein. If this was the case then "medium" levels of protein were sufficient to maintain protein mass and any additional protein absorbed was used as an energy source. Absolute energy intake will affect response to supplementation. Fattet *et al.* (1984) showed that lower energy intake led to greater loss of fat and reduced protein gains. Thus, to get protein gains under the conditions of the present study, energy intakes would have to be higher but this could lead to smaller reductions in fat.

Of significance was the non-linear loss of fat (Figure 2). This is likely to be due in part to initially low feed intakes (Figure 1). While adjustment to the diets was rapid, independence of the two effects can not be determined due to lack of ultrasound measurements for week 1. Further work should be undertaken to determine to what extent this effect is intake dependent in order to define the optimum slimming period for overfat lambs.

An important finding was the effect of gutfill on apparent weight gains. Where changes in diet quality occur, or differences between diets are being examined, care must be taken that such effects are eliminated from analyses of body weight change.

During the period of this trial, carcass value increased by 31% based on prices at 11 January 1993. At the start carcasses were TH grade (New Zealand lamb export class system, 1991) and worth \$37.40 each. At the end of the trial carcasses were graded PX and worth \$49.03 each. Cost of the food eaten was \$21, \$23 and \$26 per lamb for the three diets respectively, so increased carcass value did not cover feed costs. However, the data suggest that much of the slimming effect occurred in the first 2-3 weeks. Also these data do not preclude the use of diets containing lower levels of protein.

Further work is required to describe the pattern of fat loss and to explore the scope for feeding lower levels of dietary protein with the aim of slimming overfat lambs.

CONCLUSIONS

High levels of dietary protein are not needed to "slim" overfat lambs. The degree to which protein accretion and fat depletion can occur simultaneously appears limited.

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