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Protein content in the diet for fattening lambs.
2. The chemical and amino acid composition of the body and utilization of amino acids apparently absorbed in the small intestine

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ABSTRACT

The chemical and amino acid composition of the empty bodies of 4 lambs slaughtered before fattening and of 12 lambs from 3 gropus (4 in each group) fattened for 113 day with a diet containing 17 (H), 14 (M) or 11%(L) crude protein were determined. The amount of nitrogen and individual amino acids apparently absorbed in the small intestine during fattening was calculated on the basis of data on their passage to the duodenum and digestibility in the small intestine. No differences were found in empty body composition depending on the protein content of the diet. The mean daily deposition of protein in the empty body was: 29.7, 31.4 and 27.3 g in groups H, M and L, respectively. The utilization of protein for deposition into the empty body weihgt rose ($P \leq 0.01$) from about 18 to 27% when the protein content was decreased from 17 to 11%. The utilization of metabolic energy available for growth (Kf) was best in group M and amounted to 0.41 in comparison with 0.38 and 0.33 in groups H and L, respectively. The lowering of the protein level in the diets improved the efficiency of utilization of amino acids absorbed in the small intestine for their deposition in the empty body weight. Essential amino acids and semi-essential amino acids were best utilized by lambs from group M. From all of the amino acids, cystine and glycine were utilized best, with cystine being utilized better in groups H and M than in L. Reducing the protein content in group L to about 11% resulted in decreasing the percentage of essential amino acids in protein deposited in the body, especially in comparison with the group fed diet M.

It seems that the most effective utilization of protein takes place at a 14% crude protein content in the diet.

KEY WORDS: lambs, protein level, body composition

INTRODUCTION

Earlier studies (Jayaprakash, 1984) have shown that the chemical composition of the empty body of Polish Merino lambs fattened from about 18 to 35 kg liveweight on diets containing from 14.5 to 19% crude protein was similar. The amount and source of crude protein also did not significantly affect the empty body gain. The degree to which lambs utilize nitrogen and individual amino acids apparently absorbed in the small intestine is not well known.

The aim of this study was to elucidate the effect of reduced protein content in the diet on the chemical composition of fattened Merino lambs and to determine the utilization of nitrogen and amino acids apparently absorbed in the small intestine on liveweight gain and wool growth.

MATERIAL AND METHODS

The chemical and amino acid composition was determined of the empty bodies of 4 lambs killed at the beginning of the experiment (group 0) and of 12 lambs, 4 in each group, killed after being fed for 113 days on diets containing 17 (group H), 14 (group M) and 11% (group L) crude protein in dry matter. Details of their feeding and maintenance were described in part 1 of this study (Żebrowska et al., 1992). All of the lambs were shorn before slaughter, the greasy wool yield was determined and samples were taken for chemical analysis.

The slaughter and dissection procedures were similar to those descibed by Osińska et al. (1970) for calves, with the exception that the lambs were starved for only 24 hours before slaughter; the control lambs were not starved. Bones and connective tissue were weighed separately. The samples were autoclaved at a pressure of about 0.18 MPa, the head, legs and skin for 12 hours, the bones and connective tissue for 10 hours. Empty body weight was determined according to Garret and Hinman (1969) taking into account the amount of greasy wool.

The amino acid composition of the empty body was determined in pooled samples representative for each lamb, dried at 60^{0}C and defatted by ether extraction in a Soxhlet apparatus for 18h. The samples were hydrolysed in 6N hydrochloric acid for amino acid determination; the hydrolysates were prepared according to a modified Moore procedure (1963) for determination of sulphur-containing amino acids, while tryptophan was determined following alkaline hydrolysis. The amino acids were determined using a Beckman Unichrom Amino Acid Analyser. The chemical composition of the wool and body constituents were estimated by the Weende method, taking 6.25 as the coefficient for nitrogen.

The amounts of nitrogen and amino acids apparently absorbed in the small intestine during fattening were calculated on the basis of data on their passage to the duodenum and digestibility in the small intenstine, presented in the first part of this study (Żebrowska et al., 1992).

Net protein utilization was calculated as the protein deposition in the body and wool expressed as a percentage of protein intake. Energy utilization was similarly calculated. The energy value of the live weight gain was calculated assuming the following coefficients: 23.6 MJ/kg for protein and 39.3 MJ/kg for fat (ARC, 1980). The efficiency of protein and amino acid utilization was calculated as the percentage of the nitrogen or amino acids absorbed in the small intestine that was deposited in the liveweight gain.

The results were subjected to statistical analysis using single factor variance analysis.

RESULTS

The protein level in the diet did not significantly affect the empty body gain, although it was lower in the lambs fed the low protein diet than in the others.

The carcass weight as a percentage of net body weight was equal in the groups fed diets H and L and amounted to 53%. In the lambs fed diet M, the carcass constituted only 51.2% of the empty body weight and contained slightly more meat in comparison with the lambs from the remaining groups. The carcasses of lambs from group H contained somewhat more separable fat than the remaining ones, with the fat content being highly variable. The carcasses were rather poor in muscle and had an average separable fat content. Lowering the protein level in the diet somewhat decreased the production of greasy wool (Table 1).

The type of diet did not affect either the empty body chemical composition (Table 2) or gain (Table 3).

The mean daily protein deposition in the empty body amounted to: 29.7; 31.4 and 27.3 g in groups H, M and L, respectively. Significant differences were found

TABLE 1

Slaughter performance of lambs, kg (mean and SD)

	Diets		
	H	M	L
Live weight:			
initial	17.2 ± 1.7	16.0 ± 1.0	16.7 ± 1.0
final	38.7 ± 3.7	37.8 ± 1.6	37.4 ± 3.4
Empty body weight:			
initial	14.4 ± 1.5	13.3 ± 0.9	14.0 ± 1.0
final	32.6 ± 3.2	32.2 ± 1.4	31.2 ± 3.2
in this:			
greasy wool	1.1 ± 0.1	0.9 ± 0.1	0.8 ± 0.2
Cold carcass	17.2 ± 1.9	16.5 ± 1.3	16.6 ± 1.5
lean	10.0 ± 0.6	9.8 ± 1.1	9.6 ± 1.0
separable fat	2.6 ± 1.2	2.3 ± 0.2	2.3 ± 0.3
bone	3.7 ± 0.5	3.5 ± 0.1	3.8 ± 0.3
connected tissue	0.9 ± 0.2	0.9 ± 0.1	0.9 ± 0.2
As per cent of cold carcass:			
lean	58.1	59.3	57.9
separable fat	15.1	13.8	13.8
bone	21.5	21.2	22.7
connected tissue	5.3	5.6	5.6

TABLE 2

Chemical composition of the empty body weight (mean ± SD)

	Diets		
	H	M	L
Empty body weight, kg	32.6 ± 3.2	32.2 ± 1.4	31.2 ± 3.2
dry matter	12.2 ± 2.0	11.8 ± 0.6	11.2 ± 1.4
crude protein	6.1 ± 0.4	6.0 ± 0.2	5.8 ± 0.6
ether extract	5.2 ± 1.5	5.0 ± 0.4	4.7 ± 0.6
As per cent of empty body weight:			
dry matter	37.4 ± 2.6	36.7 ± 1.9	36.0 ± 1.5
crude protein	18.6 ± 0.9	18.7 ± 0.6	18.7 ± 0.7
ether extract	15.9 ± 3.2	15.5 ± 1.6	15.1 ± 1.4

TABLE 3

Chemical composition of the empty body gain (mean ± SD)

	Diets		
	H	M	L
Empty body gain, kg	18.2 ± 2.4	18.9 ± 2.2	17.2 ± 2.4
dry matter	7.5 ± 2.0	7.7 ± 0.6	6.8 ± 1.4
crude protein	3.4 ± 0.4	3.6 ± 0.2	3.2 ± 0.6
ether extract	3.7 ± 1.5	3.8 ± 0.4	3.4 ± 0.6
Energetic value of empty body gain, MJ	226.5	233.8	209.1
As per cent of empty body gain			
dry matter	41.1 ± 4.6	41.1 ± 3.5	39.3 ± 2.6
crude protein	18.7 ± 1.5	18.9 ± 1.1	18.5 ± 1.2
ether extract	20.1 ± 5.1	20.3 ± 3.0	19.9 ± 2.6

TABLE 4

Protein and energy utilization

	Diets		
	H	M	L
Crude protein in DM			
Crude protein intake, g	18598	14713	11663
Protein absorbed, g	14284	12030	10002
Protein deposition, g	3367	3561	3177
Net utilization of, %:			
crude protein intake	18.1	24.2	27.2
protein absorbed	23.8	29.6	31.8
gross energy	11.2	11.7	10.4
metabolizable energy	19.2	20.3	17.9

TABLE 5
Amino acid composition (g/16 g N) of fleece free empty body and clean wool of fattening lambs

Amino acid	body	wool
Asp	8.2 8.4	6.9
Thr	3.8 4.1	6.1
Ser	4.1–4.3	10.1
Glu	15.5 15.8	16.6
Pro	6.6 6.8	6.6
Gly	8.9–10.1	5.6
Ala	6.5–6.8	3.9
Val	4.8–5.1	5.5
Ile	3.2–3.4	3.4
Leu	6.6–7.1	8.0
Tyr	2.7–2.9	5.5
Phe	3.4 3.7	4.0
Lys	7.1–7.3	3.4
His	2.2–2.4	1.2
Arg	5.9–6.8	9.7
Cys	1.2–1.3	10.6
Met	1.4–1.8	0.6
Trp	0.8 0.9	0.8
N, g in EBW	849–870	97.7

($P \leqslant 0.01$) between groups H and L in the net protein utilization: when the protein content was lowered from 17 to 11%, utilization rose from about 18 to 27% (Table 4). A similar increase was found in the net protein utilization (Nx6.25) absorbed in the small intenstine, with groups H and L differing only slightly (29.6 and 31.8%, respectively).

The amino acid composition of the lamb empty body in all of the dietary groups was similar and differed markedly from the amino acid composition of the wool (Table 5). The wool protein was markedly richer in cystine and serine and poorer in lysine and methionine. The utilization of crude protein and amino acids absorbed in the small intestine was highest upon feeding the lambs diet L (Table 6). The utilization of essential amino acids by lambs in group M was better than in groups H and L. Endogenous amino acids, with the exception of serine and alanine, were utilized best by the lambs in group L.

Among all of the amino acids, cystine was best utilized, with the lambs in groups H and M utilizing it better than those in group L.

The utilization od isoleucine, methionine, tryptophan, phenylalanine and tyrosine was worse than of the remaining amino acids.

The percentages of essential amino acids in the duodenum content, in the „protein" absorbed in the small intestine and deposited in the empty body of

TABLE 6

Utilization of crude protein (N × 6.25) and amino acids absorbed in the small intestine for deposition in empty body gain, %

	Diets		
	H	M	L
(N × 6.25)	23.8	29.6	31.6
Thr	21.3	32.0	27.9
Val	20.2	25.8	24.2
Ile	14.6	20.5	20.3
Leu	19.6	27.4	27.4
Phe	15.6	22.8	21.2
Lys	25.4	32.9	28.5
His	23.7	33.4	28.6
Met	14.4	20.7	20.1
Trp	15.3	21.5	21.4
Asp	19.3	24.8	26.0
Ser	24.9	33.4	31.8
Glu	22.1	24.4	31.3
Pro	30.2	35.7	44.0
Gly	37.0	55.2	64.2
Ala	26.1	34.7	33.8
Tyr	17.8	24.7	22.5
Arg	25.9	39.8	35.7
Cys	52.5	55.2	39.4

TABLE 7

Mean content of essential amino acids in the duodenum content (d), in the protein absorbed in the small intestine (a) and deposited in the empty body gain (g), g/16 g N

AA	H			M			L		
	d	a	g	d	a	g	d	a	g
Thr	4.7	4.6	4.2	4.5	4.1	4.5	4.6	4.4	3.9
Val	5.7	6.2	5.3	5.7	5.9	5.1	5.8	6.2	4.8
Ile	4.6	5.2	3.3	4.5	5.0	3.5	4.4	4.9	3.2
Leu	7.3	8.2	6.9	7.2	7.9	7.4	7.0	7.8	6.8
Phe	4.6	5.3	3.5	4.5	5.1	3.9	4.5	5.0	3.4
Lys	5.8	6.3	6.8	5.8	6.2	6.9	6.5	7.3	6.6
His	2.2	2.3	2.3	2.1	2.1	2.4	2.2	2.2	2.0
Cys	1.7	1.2	2.7	1.6	1.1	2.1	1.6	1.6	2.0
Met	1.9	2.2	1.3	1.7	1.9	1.8	1.9	1.9	1.2
Trp	1.3	1.4	0.9	1.2	1.2	0.9	1.2	1.2	0.8

lambs fed diets H, M and L were similar (Table 7). Certain differences did become noticeable in the proportion of some of the amino acids in the content of the duodenum and deposited protein, that is, in all of the groups the proportion of isoleucine and phenylalanine was significantly lower, while that of cystine higher in the deposited protein than in the duodenum content and absorbed protein.

DISCUSSION

The lowering of the crude protein content from 17 to 14% in dry matter of feed did not affect the empty body weight and empty body gain; when the protein content was lowered to about 11%, the empty body gain was slightly decreased. The studies of Urbaniak (1986) also showed that Merino lambs which received less than 13.8% crude protein in their diets grew less than those given a diet with a higher protein content (15.9%).

The decreased production of greasy wool as the result of lowering the protein content is corroborated by the results of Urbaniak study cited above; he obtained a linear increase in wool production upon increasing the protein content from 9.3 to 15.9%.

The carcasses of lambs from group H contained somewhat more separable fat than the remaining lambs, with a very high variability of fat content being found. Veress et al. (1984) among others point out the fact that the intramuscular fat content of the carcasses of the Hungarian Merino is very variable. A similar conclusion can be drawn from the paper by Blaxter et al. (1982). The error of the regression formula for calculating the body fat content given by them is almost four times greater than for their formula for calculating the protein content; this indicates that the fat content is significantly more variable.

Shindarska (1987) showed that increasing the energy content of a feed containing 16% crude protein caused an increase in fat deposition in Bulgarian lambs from 13.7 to 27.0 g per day.

The carcasses of the lambs from the current experiment were relatively low in meat content but had an average amount of separable fat. In the carcasses of Polish Merino lambs fed diets containing 10.5 to 11.5 or 19% in the initial phase and 16.5% crude protein in dry matter in the final phase of fattening, the separable fat content was higher than in our study (13.8 — 15.1%) and amounted to about 20% regardless of the protein content of the ration (Pakulski and Osikowski, 1986, Pakulski et al., 1986a).

When Polish Merino lambs were fed according to our standards, lambs weighing 44.3 kg before slaughter had 23.1% separable fat in the empty bodies (Borys et al., 1986). In some studies (Borys et al., 1986, Korman et al., 1986, Pakulski and Osikowski, 1986, Pakulski et al., 1986b) a lower bone content was found (from about 17.5 to about 19.3% of the carcass) than in the present study (21.5-22.7%) as well as a lower meat and connective tissue content (59.3-62.0% vs 63.4-64.9%).

The chemical composition of the empty body weight and empty body gain did not depend on the protein content of the feed. Fix et al. (1988) report a similar chemical composition of the empty body weight of the German Merino and its hybrids. The empty body weight of that Merino contained: 36.4% dry matter, 18.5% protein and 13.9% ether extract.

Many studies have demonstrated that at significant differences in fat content, experimental factors had no influence on the protein content of the empty body (Searle et al., 1982, Blaxter et al., 1982, Fix et al., 1988, Urbaniak, 1986). The protein content in the empty body of the lambs in this experiment amounted to, on average, 18.5% and was higher than in the studies of Chomyszyn et al. (1960), 17.5%; Urbaniak (1986), 15.5%; Searle et al. (1982), 15%. The fat content in the empty body of lambs in the studies cited above was higher than in our experiment. Jayaprakash (1984) found a higher protein content, about 19.7%, at a similar fat content (15.6-16.5%) in the Polish Merino lambs.

Results similar to ours on the daily deposition of fat were obtained by Urbaniak (1986) when feeding diets containing from 12.1 to 15.9% protein, while when lambs were fed a diet of 10.2%, the protein content in dry matter was lower (21.1 g).

A significant increase in the utilization of crude protein ($P \leq 0.01$) was found when the protein content was decreased from 17 to 11% dry matter in the feed. Improvement in utilization of protein taken up by calves and deposited in empty body weight was found by Ziołecka et al. (1977), while in the studies of Urbaniak (1986) on lambs, no such relationship was found. Lambs fed 9.3 to 13.8% protein deposited from 20.3 to 21.4% of the protein taken up, while at a protein content of 15.9%, its deposition in empty body weight gain dropped and amounted to 17.1%.

Energy utilization was best in group M, worst in group L. After deducting the energy used for maintenance (418 kJ EM per metabolic body weight), the utilization of metabolic energy available for growth (Kf) was: 0.38; 0.41 and 0.33 in gropus H, M and L, respectively; this corroborates the results of Urbaniak (1986) for diets M and L, but is worse for diet H than in the cited study (0.38 vs 0.45).

The results of this study show that the most effective utilization of protein was at an approximate 14% crude protein content of the ration. It may be that this was affected by the energy level of the consumed diets, especially by the ratio of metabolic energy to total protein, which equalled: 65.0; 79.4 and 101.6 kJ/g in groups H, M, L, respectively.

Literature data (ARC, 1980) suggest that 65-70% of the amino acids absorbed by lambs are used for growth. If to assume that during fattening lambs utilize amino acid nitrogen to a similar degree, then the results of this experiment may suggest that about 40% of the nitrogen of amino acids absorbed was used to cover the maintenance requirement of these animals. It may be concluded that the lambs fed diet M, whose carcasses contained somewhat more meat, had better utilization of amino acids; they utilized slightly less amino acid nitrogen for maintenance processes than the lambs in the remaining groups.

In summarising the results obtained in this study it may be concluded that feeding Polish Merino lambs diets containing 14% crude protein in dry matter, did not affect the composition of the empty body, but did improve the utilization of protein and amino acids, especially the essential amino acids; their content in the deposited protein increased. Improved energy utilization was also found. Further reduction of the protein content to about 11% dry matter caused a slight deterioration of the analysed parameters, with the exception of the utilization of protein and endogenous amino acids, which were best in this group.

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STRESZCZENIE

Poziom białka w dawkach dla tuczonych jagniąt. 2. Skład chemiczny i aminokwasowy ciała oraz wykorzystanie aminokwasów pozornie wchłoniętych w jelicie cienkim

Oznaczono skład chemiczny i aminokwasowy masy ciała netto 4 jagniąt ubitych przed rozpoczęciem tuczu oraz 12 jagniąt z trzech grup (po 4 z każdej) żywionych w ciągu 113 dni tuczu dawką zawierającą 17 (H), 14 (M) lub 11 (L) % białka ogólnego w suchej masie. Ilość azotu i poszczególnych aminokwasów pozornie wchłoniętych w jelicie cienkim w okresie tuczu obliczono na podstawie danych o ich przepływie do dwunastnicy i strawności w jelicie cienkim.

Nie udowodniono różnic w składzie ciała w zależności od poziomu białka w dawkach. Średnie odłożenie białka w ciele wynosiło: 29,7; 31,4 i 27,3 g w grupach H, M i L, odpowiednio. Wykorzystanie białka na jego odłożenie w masie ciała netto wzrastało ($P \leqslant 0,01$) z ok. 18 do 27 % przy obniżeniu poziomu białka w dawce z 17 do 11 %. Wykorzystanie energii metabolicznej dostępnej dla wzrostu (Kf) było najlepsze w grupie M i wynosiło 0,41 w porównaniu z 0,38 i 0,33 w grupach H i L, odpowiednio. Obniżenie poziomu białka w dawkach poprawiło efektywność wykorzystania aminokwasów wchłoniętych w jelicie cienkim na ich odłożenie w masie ciała netto. Aminokwasy niezbędne najlepiej były wykorzystywane przez jagnięta grupy M. Ze wszystkich aminokwasów najlepiej wykorzystywana była cystyna i glicyna, przy czym cystyna była lepiej wykorzystywana w grupach H i M niż w L. Obniżenie poziomu białka w dawce L do ok. 11 % spowodowało zmniejszenie udziału aminokwasów niezbędnych w białku odłożonym w ciele, zwłaszcza w stosunku do grupy żywionej dawką M.

Wydaje się, że najefektywniej jest wykorzystywane białko przy ok. 14 % jego zawartości w dawce.