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Effect of dehydrated lucerne on lamb performance and protein and energy deposition in the body

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ABSTRACT

Forty Polish Merino lambs weighing about 17 kg were divided into five groups and fed five isonitrogenous and isoenergetic diets containing 0, 5, 10, 15, and 20% dehydrated lucerne (DL). The animals were fattened to a final live weight of about 36 kg. As the DL concentration in diets increased from 0 to 10%, a significant ($P \leqslant 0.05$) parallel rise of mean daily live weight gains from 173 to 191 g/d was observed, followed by a decrease of gains when the DL content increased to 15 and 20%. Lambs fed the 10% DL diet used the smallest amount of protein and energy for a unit of gain. The level of DL in the diet did not have a significant effect on the chemical composition and energetic value of 1 kg empty body weight (EBW). The highest value of the utilization coefficient of metabolizable energy available for growth (k_f) was found in lambs fed diets with 10% DL (0.33), and the lowest in animals from the control group (0.27). Lambs fed 10% DL deposited significantly ($P \leqslant 0.05$) more protein in EBW (29.52 g/d), in wool gain (3.90 g/d) and in total gain (33.42 g/d) than animals from the control group.

KEY WORDS: dehydrated lucerne, lambs, protein, energy deposition

INTRODUCTION

Intensive fattening of lambs requires the use of high levels of concentrates in diets as well as protein which must escape rumen degradation and be available for absorption in the small intestine (Loerch et al., 1983; Linda and Wohlt, 1985). Feeding high-concentrate or all-concentrate, low fibre, pelleted diets decreases salivary production and rumen pH, alters microbial fermentation and, therefore, dietary buffers are necessary as agents preventing acidic conditions (Linda and Wohlt, 1985; Stroud et al., 1985).

Ha et al. (1983), Stroud et al. (1985) and Urbaniak and Przybecki (1994) indicate that dehydrated lucerne (DL) can be used in diets for growing ruminants both as a buffering agent and a protein source with a limited level of ruminal degradation which increases the pH of the rumen liquid, the acetic to propionic acid ratio and the amino acid flow through the duodendum. DL is a feed rich in lysine, calcium, phosphorus and crude fibre and also has been used to replace concentrate in rations for lactating dairy cows (Christensen and Cochran, 1983; Kirkpatrick et al., 1984; Price et al., 1988).

However, few experiments were conducted concerning the effect of DL on lamb performance, body composition and protein and energy deposition in empty body weight.

The aim of this study was to determine the influence of different levels of DL in all-concentrate, pelleted diets on live weight gains, wool production and feed utilization as well as on the chemical composition of empty body weight (EBW) and protein and energy deposition in lamb body using the comparative slaughter technique.

MATERIAL AND METHODS

Forty rams of the Polish Merino breed weighing 17 kg were randomly allocated to five groups (8 animals in each) and fed five isonitrogenous (approximately 16% crude protein/kg dry matter) and isoenergetic (approximately 12.8 MJ metabolizable energy/kg dry matter) all-concentrate, pelleted diets containing 0, 5, 10, 15, and 20% of DL. The DL used in the experiment contained 19.1% crude protein, 37.8% neutral detergent fibre (NDF) and 30.6% acid detergent fibre (ADF). The lucerne was dried in a dehydrator drum with an exhaust temperature of 135^{0}C. The extent of rumen degradation of DL protein was estimated earlier by Urbaniak and Przybecki (1994) using the nylon bag technique. They found that after 24 h incubation, 61.2% crude protein of DL escaped rumen degradation. The components of the diets are listed in Table 1, while their chemical composition and energetic value are given in Table 2. The dietary metabolizable energy (ME) contents were calculated on the basis of our own results of chemical analysis using equation N^0 75 given by MAFF (1975):

$$\text{MJ ME/kg DM} = 0.012x_1 + 0.031x_2 + 0.005x_3 + 0.014x_4$$

in which x_1, x_2, x_3 and x_4 designate dietary content (g/kg dry matter) of crude protein, ether extract, crude fibre and N-free extractives, respectively.

Before the beginning of the experiment 4 additional lambs weighing 17 kg were selected, sheared and slaughtered to determine the amount of fleece and chemical composition of their body (zero group). The experimental animals were penned individually and fed one of five rations in the amount of 900 g/head^{-1}/d^{-1} (live weight of animals 17.5-25.0 kg) and later 1300 g/head^{-1}/d^{-1} (live weight of

TABLE 1

Composition of complete pelleted diets, %

Ingredient	Dehydrated lucerne, %				
	0	5	10	15	20
Dehydrated lucerne	0.0	5.0	10.0	15.0	20.0
Rapeseed meal	5.3	4.5	4.2	4.5	4.1
Ground barley	20.4	25.5	23.0	25.5	31.2
Wheat bran	30.0	30.0	27.8	20.0	18.0
Ground triticale	10.0	10.0	10.0	10.0	10.0
Ground oats	32.4	23.2	23.4	23.6	15.5
Limestone	1.5	1.4	1.2	1.0	0.8
Trace mineral salt[a]	0.3	0.3	0.3	0.3	0.3
Vitamin mixture[b]	0.1	0.1	0.1	0.1	0.1

[a] contains: NaCl – 95.8%; Zn – 0.30%; Mn – 0.38%; Fe – 0.18%; J – 0.008%; Co – 0.08%
[b] contains: 2 000 000 IU vitamin A/kg and 200 000 IU vitamin D/kg

animals 25.1-35.8 kg). Their rations were split into equal parts which were fed at 07.00 and 14.00 h. During fattening live weight and feed intake were recorded. The trial was terminated when the lambs reached a weight of about 36 kg. Then they were sheared, starved for 20 h and slaughtered. Fleece yield was determined by shearing and samples of fleece from the shoulder, flank and thigh were collected to determine the yield of clean wool. Animals from the zero group were treated similarly. The EBW of lambs was expressed as the sum of all slaughter products (including blood) subtracting the content of the digestive tract, gallbladder and bladder. The samples from each animal were autoclaved, freeze-dried and then their chemical composition and energy content were determined. Energy in wool was calculated from its chemical composition by

TABLE 2

Chemical composition (g/kg dry matter) and energetic value (MJ/kg dry matter) of diets

Item	Dehydrated lucerne, %				
	0	5	10	15	20
Dry matter[a]	881	887	879	889	892
Crude protein	162	159	159	159	160
Ether extract	38	42	39	39	38
Acid detergent fibre	120	108	115	121	127
Neutral detergent fibre	206	215	221	231	237
Crude ash	60	61	62	62	63
Metabolizable energy (ME)	12.9	12.9	12.9	12.8	12.7

[a] air dry matter basis

multiplying the quantity of protein and fat by energy value coefficients (Urbaniak and Potkański, 1987) which equal 5.609 kcal/g and 9.741 kcal/g, respectively. Energy and protein retention in lamb bodies (including wool) were calculated from the difference between the concentration of these components in the animal body at the beginning and end of the experiment.

The basic chemical composition of feeds, wool and lyophilizates of slaughter products was determined using standard methods. ADF and NDF were determined by the method of Goering and Van Soest (1970). An automatic calorimeter was used to determine the energy content in lyophilizates.

Results were analyzed statistically by analysis of variance (Steel and Torrie, 1960) with Duncan's multiple range test used to compare treatment means with significant F values.

RESULTS

No health problems were observed in the animals throughout the entire period of the experiment. With the increase of the dietary DL concentration from 0 to 10%, a significant ($P \leq 0.05$) increase of mean daily live weight gains from 173 in the control group to 191 g/d in the group fed 10% DL was observed (Table 3). Further increase of the DL share in diets to 15 and 20% slightly reduced the live weight gains to 180 and 178 g/d, respectively. Clean wool production did not differ significantly among groups, but the highest value of this parameter (4.11 g/d) was found in lambs fed diets containing 10% DL. Animals from this group used significantly ($P \leq 0.05$) less crude protein and metabolizable energy per unit of live weight gain.

The level of dietary DL did not have a significant influence on the chemical composition and energetic value of EBW (Table 4). Protein content in 1 kg EBW ranged from 181 to 184 g, fat – from 144 to 155 g, while energy value from 12.40 to 12.63 MJ. The highest value of the coefficient of utilization energy available for growth was observed in lambs fed the ration containing 10% DL (0.33), and the lowest in animals from the control group (0.27) (Table 5). Differences between groups were statistically significant ($P \leq 0.05$).

The dietary DL content had a significant ($P \leq 0.05$) effect on protein deposition in the lambs' body (Table 6). The highest quantities of protein were retained by lambs from the group fed 10% DL in diet – 29.52 g/d in EBW gain, 3.90 g/d in wool gain and 33.42 g/d of total gain, the lowest by animals from the control group – 22.43 g/d, 3.52 g/d and 27.95 g/d, respectively. Further increase of DL concentration in diets to 15 and 20% slightly reduced these parameters. Moreover, lambs from the group fed the 10% DL diet also retained significantly ($P \leq 0.05$) more protein (22.58%) than animals from the control group (18.51%).

DISCUSSION

The effect of different levels of dietary DL for fattened lambs on production results and protein and energy deposition was determined. The highest lamb live weight gains, feed utilization as well as wool production were observed when the dietary DL concentration was 10%, and then the value of these parameters decreased as the share of DL rose to 15 or 20%. Elucidation of these results can be found in the findings of Urbaniak's and Przybecki's studies (1994) in which they used these same diets with the aim to determine the effect of DL on nitrogen – energetic changes in the rumen and amino acid (AA) flow to the small intestine. The DL used in both experiments was a typical commercial product which contained 19% crude protein; 61.2% of this crude protein escaped rumen degradation. The practical significance of these findings is that the diets used in this study, containing from 0 to 20% DL, were characterized by increasing amounts of rumen non degraded AA. This was the result of, on the one hand, supplementation of the diets with increasing quantities of DL protein of relatively low rumen degradability and, on the other, the decrease in the quantities of cereal feeds (grains + bran) which undergo degradation in this forestomach much easier (Madsen and Hvelplund, 1985). Price et al. (1988) believe that the introduction of DL into diets results in the decrease of branched-chain fatty acid concentrations in the rumen. This leads to the reduction in the level of AA degradability in the rumen but also can act as a factor limiting the extent of microbial protein synthesis. Under most dietary conditions, the microbial protein synthetized in the rumen accounts for 60-85% of total AA

TABLE 3

Live weight gains, wool production and feed utilization by lambs

Item	Dehydrated lucerne, %					SE[a]
	0	5	10	15	20	
Initial weight, kg	17.5	17.7	17.6	17.7	17.5	0.9
Final weight, kg	35.6	35.8	35.8	35.7	35.7	1.9
Duration, days	105^{c}	99^{c}	95^{d}	100^{c}	102^{c}	60
Live weight gain, g/d	173^{c}	182^{d}	191^{e}	$180^{d,e}$	178^{c}	12
Feed utilization:						
crude protein, g/kg gain	876^{c}	819^{cd}	780^{d}	837^{d}	853^{b}	64
metabolizable energy, MJ/kg gain	69.9^{b}	66.4^{b}	60.9^{c}	67.6^{b}	67.8^{b}	5.0
Wool production[b], g/d	3.88	4.00	4.11	3.92	3.95	0.27

[a] standard error of the mean
[b] clean wool
[c, d, e] means in the same row bearing different superscripts differ $P \leq 0.05$

entering the small intestine (Storm et al., 1983) and can influence significantly the degree of covering AA requirements in ruminants. If the theory of Price et al. (1988) is true, then it can be assumed that under the conditions of our experiments, the main cause of the reduction of live weight gains, feed utilization as well as wool production in lambs fed 15 and 20% DL in diets could be attributed to lower microbial synthesis in the rumen. This could probably result from the too low supply of both branched-chain fatty acid and ammonia-N in the rumen. Similar beneficial effects of DL on performance in growing ruminants were also observed by other authors. Stroud et al. (1985) found that experimental steers increased their live weight gains by 18.7%, feed intake by 6.4% and its utilization by about 10%, when their diet was supplemented with 7.9% DL. Also Rock et al. (1983) and Kirkpatrick et al. (1984) observed improved ruminant performance when their diets included DL.

The present investigations did not reveal a significant effect of different DL levels in diets on the chemical composition of EBW. This fact may confirm the findings of some researchers who indicate that the chemical composition of EBW of lambs slaughtered at the same body weight is relatively stable and only slightly dependent on experimental factors (ARC, 1980; Urbaniak and Potkański, 1987; Fix et al., 1988). The content of dry matter, protein, fat, ash and energy deposited in EBW of lambs in the present study was similar to that found in other investigations carried out on lambs of the Merino type (Fix et al., 1988; Pająk et al., 1992; Urbaniak and Potkański, 1987).

Assessment of utilization of diet metabolizable energy (ME) on lamb growth using the comparative slaughter technique requires determination of the amount of energy intake, energy content in animals' body at the beginning and end of the experiment as well as maintenance requirements. With the exception of the latter, all the remaining factors were assessed in this study. It was assumed after Thericz et al. (1982), Ørskov and McDonald (1970) and Urbaniak and Potkański (1987)

TABLE 4

Chemical composition (%) and energetic value of 1 kg empty body weight of lambs

Item	Dehydrated lucerne, %					SE[a]
	0	5	10	15	20	
Dry matter	38.2	38.5	37.8	37.7	37.7	2.1
Crude protein	18.2	18.1	18.4	18.2	18.3	0.9
Ether extract	15.2	15.5	14.4	14.4	14.7	0.8
Crude ash	4.8	4.9	5.0	5.1	4.7	0.2
Gross energy, MJ/kg	12.6	12.6	12.4	12.5	12.6	0.71

[a] standard error of the mean

TABLE 5

Metabolizable energy (ME) utilization by lambs

Item	Dehydrated lucerne, %					SE[a]
	0	5	10	15	20	
Total ME intake (MJ/lamb)	1265	1203	1108	1217	1235	99
Maintenance requirement[b] (MJ)	513	483	464	488	498	31
ME available for growth (MJ)	753	719	644	729	737	52
Energy deposition[c] (MJ)	204	212	211	219	223	12
ME utilization (k_f)	0.27[d]	0.29[d]	0.33[e]	0.30[d, e]	0.30[d, e]	0.02

[a] standard error of the mean

[b] estimated: 418 kJ ME/kg $W^{0.75}$ x mean metabolic weight x duration

[c] wool included

[d, e] means in the same row bearing different superscripts differ $P \leq 0.05$

TABLE 6

Protein deposition in lambs' body

Item	Dehydrated lucerne, %					SE[a]
	0	5	10	15	20	
Protein intake, g/d	151	150	148	151	152	10
Protein deposition:						
in EBW gain, g/d	24.4[b]	26.4[b]	29.5[c]	27.5[c]	27.4[c]	1.17
in wool gain, g/d	3.5[b]	3.7[b]	3.9[c]	3.7[b]	3.7[b]	0.16
total, g/d in % of protein	27.9[b]	30.2[c]	33.4[d]	31.1[d]	31.1[d]	2.02
intake	18.5[b]	20.1[b]	22.6[c]	20.6[c]	20.5[b]	1.11

[a] standard error of the mean

[b, c, d] means in the same row bearing different superscripts differ $P \leq 0.05$

that maintenance requirements amounted to 418 kJ/kg $W^{0.75}$. In the present study the highest value of the k_f coefficient was recorded in lambs fed diets containing 10% DL. Blaxter and Boyne (1978) maintain that the utilization of dietary energy depends not only on the **q** value (ME/GE), but also on the content of total protein and crude fibre. In this experiment all diets had similar values of these parameters and differed only in the concentration of DL. Therefore, under these conditions, the fact that the lambs from the group fed diets containing 10% DL obtained the maximum value of the k_f coefficient indicates explicitly that the level of supplementation was optimal. The values of k_f obtained in the present study correspond with the results of other authors (Thomson and Cammel, 1979; Theriez et al., 1982; Urbaniak and Potkański, 1987). The total quantity of the protein deposited in the lambs' body (EBW gain + wool gain) increased from 27.95 g/d to 33.42 g/d when the concentration of dietary DL increased from 0 to 10%, and decreased when the dietary DL concentration increased further, i.e. to 15 and 20%. The observed tendency was similar as in the case of utilization of ME for growth and production results. The quantity of protein deposited by lambs corresponded with the N retention in growing sheep in the experiments of Ørskov and Grubb (1979) and Amos and Evans (1980), 4.6-6.2 and 3.7-6.2 g/d, respectively which was determined by traditional methods (collection of faeces and urine), as well as with the results of studies by Urbaniak and Potkański (1987) and Pająk et al. (1992) in which the comparative slaughter technique was employed.

Summarizing, it may be concluded that under the conditions of this study the optimal level of DL in all-concentrate, pelleted diets was 10%. This level of supplementation gave the best production results and the highest deposition of protein and energy in animals' body.

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STRESZCZENIE

Wpływ suszu z lucerny na wyniki produkcyjne jagniąt oraz odłożenie białka i energii w ciele

Czterdzieści tryczków rasy merynos polski, ważących około 17 kg, podzielono na 5 grup i żywiono pięcioma izobiałkowymi i izoenergetycznymi dawkami zawierającymi 0, 5, 10, 15 lub 20% suszu z lucerny (DL).

Zwierzęta tuczono do końcowej masy ciała około 36 kg. Wraz ze wzrostem udziału DL w dawkach od 0 do 10% istotnie ($P \leqslant 0.05$) wzrosły średnie dzienne przyrosty masy ciała, odpowiednio od 173 do 191 g/d. Przy zwiększeniu zawartości DL w dawkach do 15 i 20% przyrosty dzienne obniżyły się do 180 i 178 g. Jagnięta żywione dawką zawierającą 10% DL zużywały mniej białka i energii na jednostkę przyrostu niż z pozostałych grup. Udział DL w dawkach nie miał istotnego wpływu na skład chemiczny i wartość energetyczną 1 kg masy ciała netto (MCN). Najwyższą wartość współczynnika wykorzystania energii metabolicznej na wzrost (k_f) stwierdzono u jagniąt żywionych dawką zawierającą 10% DL (0.33), najniższą u jagniąt z grupy kontrolnej (0.27). Jagnięta otrzymujące w dawce 10% DL odkładały istotnie więcej ($P \leqslant 0.05$) białka w MCN (29.5 g/d), w przyroście wełny (3.9 g/d) i w całkowitym przyroście (33.4 g/d) niż zwierzęta grupy kontrolnej.