Journal of Animal and Feed Sciences, 10, Suppl. 2, 2001, 357 – 362

Effect of extrusion-cooking temperature on the nutritive value of lupin seeds in fattening lambs

J. J. Pająk, J. Kowalczyk, T. Żebrowska, B. Kowalik and Z. Długołęcka

The Kielanowski Institute of Animal Physiology and Nutrition, Polish Academy of Sciences 05-110 Jabłonna, Poland

ABSTRACT

Twelve Polish-Merino lambs, divided into two groups of 6, were fattened from 18 to 39 kg body weight on diets containing 14% crude protein and 11% crude fibre in dry matter; 25% of crude protein was from untreated lupin seeds or a mixture of lupin extruded at 160°C with barley (1:1). Daily body weight gains of lambs fed extruded lupin seeds were higher ($P<0.5$) than those of lambs fed the untreated lupine-barley mixture (234 vs 186 g). Feed efficiency was 5.0 kg dry matter and 729 g crude protein in lambs fed the untreated lupine-barley mixture and 4.2 kg dry matter and 597 g crude protein in animals receiving the extruded mixture.

Effective protein degradability of untreated lupin was 0.85, untreated barley 0.75 or untreated lupin-barley mixture 0.80, whereas that of extruded at 130, 140, 150 or 160°C lupin-barley mixtures gradually decreased from 0.70 to 0.67. The respective effective protein degradability values for barley extruded at 135 or 155°C were 0.72 and 0.60. The coefficient of intestinal protein digestion of untreated lupine was 0.59, of barley, 0.83, and of the lupin-barley mixture, 0.71, whereas for extruded lupin-barley mixtures, it only slightly increased with temperature from 0.92 to 0.94, while for extruded barley from 0.91 to 0.92.

Substitution of unprocessed lupin seeds with extruded seeds decreased protein degradation in the rumen, increased protein intestinal digestibility and effectiveness of fattening lambs. Increasing the extrusion temperature to over 130°C did not significantly improve degradability in the rumen or intestinal digestibility of protein.

KEY WORDS: extrusion-cooking temperature, lupin seeds, fattening lambs

INTRODUCTION

Lupin seed protein is rapidly degraded in the rumen, which is why it is poorly utilized. One of the ways of limiting its degradation is extrusion. An additional benefit from extruding feeds containing easily digested protein, aside from limiting the extent of its degradation in the rumen, is the resulting rise in true ileal protein digestibility (Cros et al., 1991; Kibelolaud et al., 1993).

The objective of this experiment was to examine the influence of extrusion-cooking temperature on the effective degradability and ileal digestibility of rumen undegraded yellow lupine seeds and to see if extruding lupin seeds improves protein utilization by growing lambs.

MATERIAL AND METHODS

Twelve Polish Merino male lambs about 85 days old and weighing about 18 kg were divided into two groups of six animals each. The ration, containing 14% crude protein (CP) and 11% crude fibre in dry matter (DM), provided: meadow hay, 10; whole barley grain, 66; dried sugar beet pulp, 14%. In the control group (RL) the ration was supplemented (about 25% CP of the ration) with untreated yellow lupin cv. Juno, in the experimental group (EL), with lupin extrudate (extruder INSTA-PRO 600).

The extrudates used to study the effect of extrusion temperature on the effectiveness of protein degradation in the rumen (deg) and the ileal digestibility of rumen undegraded protein (dsi) were prepared from barley meal (50%) and lupin cv. Juno meal (50%) at extrusion temperatures of 130, 140, 150 and 160°C. Lambs were fed the extrudate that was characterized by the lowest rumen protein degradability and highest ileal digestibility, prepared at a temperature of 160°C. The feed was given twice daily, normalizing the daily DM ration according to body weight (BW) of the lambs using the following equation:

$$DM_{(kg)} = (41.9 \times BW_{(kg)} - 217.6) \times 0.0011$$

Both groups received the same mineral-vitamin supplement of Polfamiks O and Mikrofos. The animals were housed individually on sawdust and had free access to water and salt blocks.

Rumen protein degradation was determined according to Mehrez and Ørskov (1977). Effective rumen protein degradation at $k_{0.06}$ was computed according to Ørskov and McDonald (1979). Ileal protein digestibility of rumen-undegraded protein was determined according to Hvelplund et al. (1992) by the mobile nylon bag method (mesh size 42 μm). Analysis of feeds was carried out using AOAC (1990)

methods. Daily body weight gain, DM and CP utilization over 100 days of fattening were determined.

RESULTS AND DISCUSSION

An increase in the extrusion temperature of a lupin-barley mixture caused a slight decline in the effective degradation of protein in the rumen and a non-significant increase in the intestinal digestibility of rumen undegraded protein (Table 1).

TABLE 1

Influence of increasing extrusion-cooking temperature on ruminal degradability (deg), intestinal digestibility of rumen undegraded protein (dsi) and PDI value, g/kg DM

Indices	Lupin seeds	Extrusion-cooking temperature of lupin-barley (1:1) mixture				
		untreated	130°	140°	150°	160°
Crude protein, g/kg DM	410	270				
deg	0.85	0.80	0.70	0.68	0.67	0.67
dsi	0.59	0.71	0.92	0.93	0.94	0.94
Degraded in rumen, g	349	216	188	185	182	180
Digested in intestine, g	36	38	76	81	84	85
PDIN, g	237	164	188	190	192	193
PDIE, g	110	112	153	157	160	162

Extrusion of the lupin-barley mixture decreased effective rumen protein degradation (to 0.67) in comparison with raw lupin seeds (0.85) and barley grain (0.75) or raw lupin-barley mixture. These results are similar to those of Cros et al. (1991) and Kibelolaud et al. (1993), who found a decline in rumen protein degradation after extrusion of white lupin at temperatures ranging from 110 to 195°C. An increase in extrusion temperature improved intestinal digestibility of extrudate protein and of PDIN 10 to 32%, and PDIE 57 to 194% (Cros et al., 1991).

Extrusion lowered the amount of protein degraded in the rumen by about 13-17% of the amount degraded from the unextruded mixture (216 vs 180-188 g/kg DM). In our experiment, the amount of protein digested in the small intestine after extrusion rose over twofold from 38 to 76-85 g/kg DM. We also observed a 15-18% rise in the PDIN value in the extruded mixture in comparison with the value computed for the mixture not subjected to this process; PDIE rose 37-45%.

Increasing the temperature of barley extrusion from 135 to 155°C decreased amount of protein degraded in the rumen by 4 and 20%, respectively, and increased

amount of rumen undegraded protein digested in small intestine by 25 and 80%, respectively, in relation to the respective value for untreated barley (Table 2).

TABLE 2

Influence of extrusion-cooking temperature of barley grain protein degradability, intestinal digestibility and PDI value, g/kg DM

Indices	Extrusion-cooking temperature of barley		
	untreated	135°C	155°C
Crude protein, g/kg DM		137	
deg	0.75	0.72	0.60
dsi	0.83	0.91	0.92
Degraded in rumen, g	103	99	82
Digested in intestine, g	28	35	50
PDIN, g	89	93	100
PDIE, g	102	109	124

Table 3 presents the nutritive value of DM rations determined for the period of 100 days of fattening. At a similar crude protein content (143-145 g in DM) in the rations, the amount of protein digested in the small intestine was 11% higher when ration EL was fed than RL, similarly, the PDIN content in the ration for group EL lambs was about 15% higher than for the control lambs.

TABLE 3

Protein degradability and intestinal digestibility of rumen undegraded protein and nutritive value of rations, g/kg DM

Indices	Group	
	control	experimental
Crude protein in ration, g	145	143
Protein degraded in the rumen, g	100	96
Protein digested in small intestine, g	35	39
PDIN, g	93	107
PDIE, g	104	126
UFV	1.1	1.2

Body weight gains in the experimental group lambs were about 25% higher than in the control group (Table 4). Feed utilization was better by 16 (DM) to 18% (CP) in the group receiving the extrudate than in the control group. Sanson (1992) obtained similar results when feeding soyabean meal extrudate.

TABLE 4

Fattening performance of lambs and feed efficiency

Indices	Group		SEM
	control	experimental	
Body weight, kg			
initial	18.1	18.1	0.75^{NS}
final	36.8	41.0	1.40^{NS}
Fattening period, days	101	98	1.4^{NS}
Daily body gain, g	186[a]	234[b]	$13.8^{P\leq0.05}$
Feed intake/kg of gain			
dry matter, kg	5.0	4.2	0.41^{NS}
crude protein, g	729	597	57.5^{NS}

CONCLUSIONS

Increasing the temperature of extrusion of yellow lupin seeds and barley grain decreases rumen protein degradation and markedly increases the amount protein undegraded in rumen and protein digested in small intestine.

Replacing lupin seeds with their extrudate increases the growth rate of lambs and leads to better feed utilization.

REFERENCES

AOAC, 1990. Association of Official Analytical Chemists. Official Methods of Analysis. 15th Edition. Arlington, VA

Cros P., Benchaar C., Bayourthe C., Vernay M., Moncoulon R., 1991. In situ evaluation of the ruminal and intestinal degradability of extruded whole lupin seed nitrogen. Reprod. Nutr. Develop. 31, 575-583

Hvelplund T., Weisbjerg M.R., Andersen L.S., 1992. Estimation of the true digestibility of rumen undegraded dietary protein in the small intestine of ruminants by the mobile bag technique. Acta Agr. Scand., Sect. A, Anim. Sci. 42, 34-39

Kibelolaud A.R., Vernay M., Bayourthe C., Moncoulon R., 1993. Effect of extruding on ruminal disappearance and lower gastrointestinal tract digestion of white lupin seeds. Can. J. Anim. Sci. 73, 571-579

Mehrez A.Z., Ørskov E.R., 1977. A study of the artificial fibre bag technique for determining the digestibility of feeds in the rumen. J. Agr. Sci. 88, 645-650

Ørskov E.R., McDonald I., 1979. The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of pasage. J. Agr. Sci. 92, 499-503

Sanson D.W., 1992. Utilization of a low-quality native hay by sheep supplemented with extruded soybeans. Proc. Western Section, Amer. Soc. Anim. Sci. 43, 491-494

STRESZCZENIE

Wpływ temperatury ekstruzji na wartość pokarmową nasion łubinu w tuczu jagniąt

Dwanaście jagniąt merynosa polskiego od 18 do ok. 39 kg masy ciała żywiono dawką zawierającą 14% białka ogólnego i 11% włókna surowego w suchej masie. W białku ogólnym dawki 25% stanowiło białko nasion łubinu żółtego lub białko ekstrudowanej w temperaturze 160°C mieszanki ziarna jęczmienia i nasion łubinu (1:1). Efektywny rozkład w żwaczu białka mieszaniny jęczmienno-łubinowej wynosił 0,67-0,70; białka nasion łubinu 0,85; ekstrudowanego ziarna jęczmienia 0,60-0,72 i śruty jęczmiennej 0,75. Zwiększenie temperatury ekstruzji z 130 do 160°C spowodowało niewielkie tylko zmniejszenie degradacji w żwaczu białka mieszanki jęczmienno-łubinowej z 0,70 do 0,67 i nieistotnie zwiększyło strawność jelitową białka nie rozłożonego w żwaczu z 0,92 do 0,94.

Dzienne przyrosty masy ciała jagniąt żywionych dawką z ekstrudowanymi nasionami łubinu były większe niż jagniąt karmionych dawką ze śrutą łubinową (234 vs 186 g; $P<0.05$). Jagnięta otrzymujące ekstruderat zużywały 4,2 kg s.m. i ok. 600 g białka ogólnego, jagnięta kontrolne 5,0 kg s.m. i ok. 730 g białka ogólnego na kg przyrostu.

Zastąpienie nasion łubinu ekstruderatem obniżyło stopień degradacji białka w żwaczu oraz zwiększyło efektywność tuczu jagniąt. Zwiększenie temperatury ekstruzji powyżej 130°C nie miało istotnego wpływu na wielkość rozkładu w żwaczu oraz strawność jelitową białka.