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**EFFECTS OF RUMINAL DEGRADABILITY OF
PROTEIN SUPPLEMENTS ON NUTRIENT
DIGESTION
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IN LAMBS FED GRASS OR
CORN SILAGE**

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Introduction

Silages, when fed alone, suffer from low intake and poor digestion, and supplementation of protein is often necessary to achieve a satisfactory level of production. The protein content in rations offered to ruminants received considerable attention in the past, but recent research has tended to concentrate on the quality of feed protein. A new system based on the proportion of protein degraded in the rumen (degradability, dg value) has been suggested for calculating protein requirements¹⁾ and it has been adopted in the ARC allowance²⁾. Degradability of protein is associated with the microbial activity in the rumen, hence digestion and utilization of feed by hosts. Thus, the dg value of protein supplement may have an effect on nutrient digestion and nitrogen utilization of silage.

On the other hand, the dg value has been recognized to vary in different silage. The protein of grass silage is rapidly and highly degraded in the rumen and corn silage is comparatively low in the dg value³⁾. Usually, corn silage is lower in nitrogen content than grass silage and the responses of nutrient digestion and nitrogen utilization of corn silage to supplements may be different from those of grass silage.

The present study was purposed to compare the effects of ruminal degradability of protein supplements on the nutrient digestion and nitrogen utilization in lambs fed grass or corn silage. Supplements were soybean meal

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(a more degradable protein) and corn gluten meal (a relatively undegradable protein).

Materials and Methods

Four yearling lambs, weighing about 40–50 kg, were used. Their managements were the same as described in the previous study⁹.

Grass silage were made of orchardgrass cut at blooming stage in an air-tight silo. Grass was allowed to wilt before ensilage. Corn silage was made of corn whole crop cut at a yellow stage in an air-tight silo.

Three dietary treatments for each silage were: silage alone (GS, CS) or supplemented with soybean meal (GS-SBM, CS-SBM) or corn gluten meal (GS-CGM, CS-CGM) (Table 1). Two diets with silage alone were offered to meet the ME requirement for maintenance and other protein-supplemented diets to achieve 100 g of daily gain according to ARC allowance¹⁰. Amount of grass silage offered was 2.5 kg per day at maintenance, but due to a silage refusal it was lowered to a level of 2.0 kg per day in two supplementary treatments. Corn silage was offered at a level of 2.8 kg per day for all of three treatments. The daily supplemented level is 100 g for SBM and 80 g for CGM to offer the supplemented diets of each silage isonitrogenously. Ground wheat was also added to meet the energy requirement.

TABLE 1. Ingredient and composition of experimental diets

	Treatment					
	GS	GS-SBM	GS-CGM	CS	CS-SBM	CS-CGM
Ingredient	g/d, as fed					
Grass silage	2,500	2,000	2,000	—	—	—
Corn silage	—	—	—	2,800	2,800	2,800
Soybean meal	—	100	—	—	100	—
Corn gluten meal	—	—	80	—	—	80
Ground wheat	—	300	320	—	130	150
Composition ¹⁾	%					
DM	35.8	41.7	41.8	37.6	32.4	32.5
OM	87.8	91.2	91.7	93.7	92.8	93.3
CP	12.4	16.0	16.6	9.5	14.0	14.6
CWC	68.4	48.0	47.5	44.3	42.4	41.6
ADF	45.0	26.4	25.8	26.7	22.9	22.3

1) All values except percent DM are on a DM basis.

Experiment was divided into six periods. In period 1, grass silage was fed to all of 4 lambs and in period 4 corn silage was given. Change-over experiment was carried out for GS-SBM and GS-CGM in periods 2 and 3, and for CS-SBM and CS-CGM in periods 5 and 6.

Details of digestion and metabolism trials, and analysis procedure of chemical compositions have been described elsewhere⁹.

Effective degradability in the rumen for each diet was measured with nylon bag technique in two rumen-cannulated Holstein calves at age of one year. The detail of measurement has been given by OKUBO *et al.*⁵.

Results were analyzed as a two-way factorial design by the method of STEEL and TORRIE⁹.

Results

Intake and Digestibility

Dry matter intake and digestibility are presented in Table 2. The lamb did not completely consume the GS given at maintenance level but there was no orts in the other treatments. The apparent digestibility of DM, organic matter (OM) and crude protein (CP) significantly increased in each supplemented diet of both silages ($P < 0.01$) compared to each silage given alone, but there was no significant difference between supplements. Supple-

TABLE 2. Dry matter intake and apparent digestibility of nutrients

	Treatment						Significance ¹⁾ of effect		
	GS	GS-SBM	GS-CGM	CS	CS-SBM	CS-CGM	Sil.	Sup.	S×S
Dry matter intake, g/d	749	994	1,002	792	982	984			
Digestibility, %									
DM	54.7	67.0	65.8	58.4	69.6	69.3	*	**	NS
OM	54.9	70.0	68.4	60.8	71.9	71.5	*	**	NS
CP	51.7	69.3	68.8	50.7	69.4	70.2	NS	**	NS
CWC	54.4	55.1	53.1	27.5	47.1	45.7	**	**	**
ADF	54.0	52.4	51.4	31.1	46.9	44.9	**	*	*

1) Sil.: Silage effect

Sup.: Supplementation effect

S×S: Interactions between silage and supplementation

*: Significant at $P < 0.05$

** : Significant at $P < 0.01$

NS: Not significant

mentation had no significant effect on cell wall constituents (CWC) digestibility ($P > 0.05$) and slightly depressed acid detergent fiber (ADF) digestibility in GS-SBM and GS-CGM, while digestibilities of CWC and ADF significantly increased with supplementation in CS-based diets ($P < 0.01$).

N Utilization

The GS had a higher N degradability than CS (Table 3). The SBM-supplemented diets showed higher dg value than the CGM-supplemented diets for both silage, but there was no difference in dg value between those diets with a same supplement (Table 3).

Either supplementation increased daily N intake with associated increase

TABLE 3. Nitrogen balance of lambs and degradability of each diet in the rumen

	Treatment						Significance ¹⁾ of effect		
	GS	GS-SBM	GS-CGM	CS	CS-SBM	CS-CGM	Sil.	Sup.	S×S
	g/d								
N intake	14.9	25.4	26.6	12.0	22.0	23.0	NS	**	NS
Fecal N	7.2	7.8	8.3	5.9	6.7	6.9	NS	**	NS
Urinary N	5.4	12.4	11.6	3.5	7.5	7.8	*	*	NS
N retention	2.3	5.2	6.7	2.6	7.8	8.3	**	**	NS
	%								
Nr/Ni	15.7	20.3	25.3	21.5	35.3	36.1	**	**	NS
Nr/DNI ²⁾	29.9	29.5	36.6	42.6	51.0	52.0			
Degradability									
Nitrogen	70.0	66.4	48.8	63.8	67.9	51.2			
DM	38.5	51.5	51.0	56.0	63.2	59.2			
	g/kg								
RDN/ADOM ³⁾	41.0	36.0	28.0	18.0	26.0	22.0			

- 1) Sil. : Silage effect
 Sup. : Supplementation effect
 S×S : Interactions between silage and supplementation
 * : Significant at $P < 0.05$
 ** : Significant at $P < 0.01$
 NS : Not significant

- 2) DNI : Digestible nitrogen intake
 Nr : Nitrogen retention

- 3) RDN : Ruminal degradable nitrogen

ADOM: The estimated organic matter (OM) apparently digested in the rumen, assuming ruminal degradability of OM is equal to that of dry matter

in N excreted in urine and feces, but also with substantial increases in N retention for both silages (Table 3). There was no difference in fecal N between supplements for both silages. The GS-SBM diet had more urinary N loss and less N retention (Nr) than GS-CGM while there was no difference in N utilization between two supplemented CS diets.

Discussion

The grass silage used in the present experiment was of poor quality in terms of digestibility (Table 2). Either supplementation significantly increased the apparent digestibility of DM, OM and CP ($P < 0.01$), compared with GS given alone, but there was no significant difference between supplements. The results of digestion trial for CS were similar to that for GS. GILL and ENGLAND² observed no difference in the digestibilities of DM, OM and N in young cattle when grass silage was supplemented isonitrogenously with fish meal or groundnut meal. Several workers^{10,11} have also shown that the digestibility of DM and N were not affected by protein sources with different dg value, though they used corn cob as basal diet.

The higher Nr of lambs given supplemented diets compared to those given silage alone may, partly, be contributed to the increase in N intake (Table 3). The Nr of lambs given GS-CGM was superior to those given GS-SBM, while the case was not found in CS. When Nr was expressed as a percentage of digestible N intake, GS-CGM diet was superior to the GS and GS-SBM diets, with little difference between GS and GS-SBM (Table 3). These results may be associated with the supply of N and energy source to the microbes in the rumen.

The efficiency of microbial nitrogen (MN) synthesis has been shown to be 25-27 g/kg OM apparently digested in the rumen (ADOM) in sheep given silage^{4,6,8}. Assuming the efficiency of conversion of ruminal degradable nitrogen (RDN) into MN is 1.0, the ratio of RDN to ADOM should be near 25-27 g/kg to maximize the microbial activity and to minimize the N loss. When GS was given alone, the estimated RDN/ADOM was 41 g/kg (Table 3), which is much higher than the value of efficiency of microbial protein synthesis. Supplementation improved the balance of supply of N and energy to the ruminal microbes. However, the value of RDN/ADOM was higher in GS-SBM diet than that in GS-CGM. It is likely to exist a oversupply of N to the microbes in the rumen of lambs given GS-SBM. This resulted in more N lost in urine of lambs given GS-SBM than those given GS-CGM.

So far as CS concerned, the ratio of RDN to ADOM was low, indicating

a shortage of N supply relative to energy. The harmony in the supply of N and energy with supplementation resulted in higher digestibility of nutrients and more N retained by lambs. Because the difference of RDN/ADOM between CS-SBM and CS-CGM was not large, and moreover either RDN/ADOM was in the range of the efficiency of microbial protein synthesis, there was no difference of Nr between CS-SBM and CS-CGM.

In conclusion, such silage with high dg value as GS should be supplemented with such a protein source of low dg value as CGM in terms of N utilization, while the dg value of supplementary protein is not important to silages with medium dg value such as CS.

Summary

This experiment was conducted to study the effects of protein degradability of supplements on nutrient digestion and nitrogen utilization in lambs fed grass silage (GS) or corn silage (CS). The GS or CS was given either alone at maintenance level or supplemented isonitrogenously with soybean meal (SBM) or corn gluten meal (CGM). Both supplements significantly increased the apparent digestibility of dry matter, organic matter and crude protein of each supplemented diet ($P < 0.01$), compared with each silage given alone, but there was no significant difference between supplements ($P > 0.05$). Nitrogen retention also increased ($P < 0.01$) in each supplemented diet for both silages. Supplementation of GS with SBM resulted in more nitrogen loss in urine, hence less nitrogen retention, than that with CGM, but the case was not found in CS. The results suggest that such silages with high degradability of protein as GS should be supplemented with a protein source of low degradability such as CGM, while the degradability of supplementary protein is not important to the silages with medium degradability of protein such as CS.

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