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EFFECT OF RUMINAL DEGRADABILITY OF PROTEIN SUPPLEMENTS ON VOLUNTARY INTAKE OF GRASS OR CORN SILAGE BY SHEEP

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Introduction

Voluntary intake of silage have been shown to be lower than that of the corresponding crop fed fresh[5] or after drying[4,9,22]. Low intake of silages can not be explained with only fermentation characteristics[14,15]. Several workers have shown evidence that physical fill of the rumen is important in limiting the silage intake[6,8,24].

Supplementation of silages with protein has in some cases been shown to increase silage intake[12,18,21]. There is, however, little information in effect of degradability of protein supplements on voluntary intake of silage. On the other hand, cereal supplements have been shown to have the effects of decreasing silage dry matter intake[23], while adequate amount of easily available carbohydrate may improve the balance of supply of N and energy available for the ruminal microbes.

This study was conducted to clarify the effect of ruminal degradability of protein supplements on voluntary intake of grass or corn silage by sheep. Soybean meal (SBM) and corn gluten meal (CGM) were used as more degradable and relatively undegradable protein supplements, respectively. Along with protein supplements, ground wheat was added as a carbohydrate source easily available for the microbes in the rumen.

Materials and Methods

Animal

Animals used were four castrated Suffolk cross sheep, weighing about 40–50 kg. They were individually kept in a metabolism crate. Daily feeds were offered in two equal meals at 09:00 and 17:00 hours. Water and

mineralized salt block were freely available.

Diets and Experimental Design

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

Three dietary treatments for each silage were: (1) silage alone, (2) supplemented with soybean meal or (3) corn gluten meal (Table 1). Each silage was ad libitum offered and the amount given was calculated to exceed that eaten on the previous day by about 10% to avoid selective feed intake. The daily supplemented level was 100 g for SBM and 80 g for CGM to offer the supplemented diets of each silage isonitrogenously. Ground wheat was also added to keep the balanced supply of N and energy to the ruminal microbes.

TABLE 1. Component of the experimental diets

Silage	Grass			Corn		
Treatment	GS	GS-SBM	GS-CGM	CS	CS-SBM	CS-CGM
	g/d, as fed					
Grass silage	ad libitum			—	—	—
Corn silage	—	—	—	ad libitum		
Soybean meal	—	100	—	—	100	—
Corn gluten meal	—	—	80	—	—	80
Ground wheat	—	200	220	—	200	220

Sampling and Analysis

Experiment was conducted in six periods. Each period lasted for 19 days and silage intake was measured for the last 5 consecutive days. During the determination period, daily sample of feeds offered was taken and daily residues were removed, weighted and sampled before morning feeding. Feeds and weighback were analyzed for dry matter (DM), organic matter (OM) and nitrogen (N) with the methods described by AOAC[3] and cell wall constituents (CWC) by the method of GOERING and VAN SOEST[11]. Fermentation quality of silage was assessed on both Flieg's index and the pH value.

Results were analyzed as a two-way factorial design by the method of STEEL and TORRIE[20].

Results

Chemical Composition and Fermation Characteristics

Table 2 presents chemical composition of silages and supplements. The N content in GS was similar to that in CS and CWC content was 63.6 and 40.4% for GS and CS, respectively.

Fermentation characteristics of silage are presented in Table 3. The GS had a slightly higher pH value than CS (4.51 vs. 4.10). Total acid content was higher in GS than in CS (4.48% vs. 1.59%, as is basis), resulting from the higher lactic acid content in GS than in CS. Butyric acid content was low for both silages. Flieg's index was 75 and 65 for GS and CS, respectively.

TABLE 2. Chemical composition of feeds used

Feeds	DM	OM	N	CWC
	%		%, DM	
Grass silage	40.1	90.9	1.49	63.6
Corn silage	27.3	93.4	1.44	40.4
Soybean meal	87.1	93.4	7.71	10.7
Corn gluten meal	90.0	98.4	10.42	3.0
Ground wheat	85.2	95.6	2.14	11.5

TABLE 3. Fermentation characteristics of silages used

Silage	pH	Acids (%, as is basis)				Flieg's index
		Total	Lactic	Acetic	Butyric	
Grass	4.51	4.48	3.53	0.54	0.41	75
		(100)[1)]	(77)	(15)	(8)	
Corn	4.41	1.59	0.98	0.60	0.02	65
		(100)	(50)	(49)	(1)	

1) The figures in parentheses indicate the proportion of individual organic acid to the total.

Voluntary Intake

Table 4 shows the intake of each silage and the total intakes of DM, OM, N and CWC of each diet by sheep.

Voluntary intake of GS given alone approximated to that of CS. Either supplementation increased total DM intake, the intakes of OM, N ($P<0.01$)

TABLE 4. Daily intakes of each silage and diet by sheep

Silage	Grass			Corn			Significance[1] of effect		
Treatment	GS	GS-SBM	GS-CGM	CS	CS-SBM	CS-CGM	Sil.	Sup.	S×S
Intake, g/d									
DM									
Silage	917.3	1000.1	1043.8	938.1	1065.9	1068.5	NS	NS	NS
Total	917.3	1255.7	1300.9	938.1	1326.3	1330.7	NS	**	NS
OM	833.7	1150.4	1195.5	876.3	1246.6	1255.1	NS	**	NS
Nitrogen	13.7	26.1	28.2	13.5	25.8	26.7	NS	**	NS
CWC	583.8	668.7	690.9	378.7	477.3	473.8	**	*	NS
Relative intake, g/kg$^{0.75}$									
DM									
Silage	53.4	58.2	60.8	50.3	56.9	57.2	NS	*	NS
Total	53.4	73.1	75.8	50.3	70.8	71.2	NS	**	NS
CWC	34.0	38.9	40.2	20.8	25.5	25.4			

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.

and CWC ($P<0.05$) for GS-based and CS-based diets. There was no significant difference of intake between the protein supplements ($P>0.05$). Supplementation increased voluntary intake of each silage and this increase was significant ($P<0.05$) when expressed on the basis of the metabolic body weight.

Discussion

The GS used in the present experiment was high in CWC content and low in N content (Table 2), being equivalent to a crude protein content 9.3% of DM. This may be due to a later harvest stage of parent material. The voluntary intake of GS given alone was 53.4 g DM/kg body weight$^{0.75}$, and similar to results reported in the previous study[15]. Corn silage used was of comparatively poor quality with a lower Flieg's index than grass silage (Table 3). Voluntary intake of CS given alone was 50.3 g DM/kg body weight$^{0.75}$ and lower than that in the previous study[15].

Intake of CWC in GS-based diets was higher than in CS-based diets

(Table 4). MERTENS[17] observed that sheep ate a constant amount of CWC of approximately 40 g/kg live weight$^{0.75}$ which is similar to the values obtained in this experiment with GS-based diets but not with CS-based diets.

Either supplementation increased voluntary intake of GS and CS ($P<0.05$). This increase may result from the improved supply of N available for the microbes in the rumen. Silage contains a large proportion of non-protein nitrogen, which is degraded rapidly in the rumen[1], along with a low content of soluble carbohydrate. The ingestion of silage is followed by a pronounced peak in the rumen ammonia concentration[7,19,21]. The ruminal microbes is not able to make full use of the high concentration of ammonia-N and a large part of the ammonia-N is absorbed, converted to urea and excreted in the urine[15,16,22]. This may result in the undersupply of N to the ruminal microbes in later period after a meal, suppress the cellulolytic activity in the rumen and decrease the silage intake. Protein supplements ensured the sufficient supply of N to the ruminal microbes and increased the rate of digestion of fibrous fractions in the rumen, and hence silage intake.

There was little difference in voluntary intake of grass or corn silage between supplements (Table 4). In the previous study[16], more N was lost in the urine of lambs fed grass silage supplemented with SBM than with CGM. When grass silage was supplemented with SBM of high degradability, ruminal degradable protein might exceed the level at which the microbes could utilize it and excess ammonia would be absorbed and excreted in the urine. With CGM supplementation, ruminal degradability of dietary protein was lower and ineffective N utilization would not occur. Both supplements were, however, considered to satisfy the N requirement for the microbes in the rumen and the voluntary intake of each silage increased to same extent.

GILL and ENGLAND[13] observed that there was no difference in voluntary intake of grass silage by growing cattle between protein supplements, although they used fish meal and groundnut meal as supplements. GARNSWORTHY and JONES[10] found no significant difference in DM intake of hay-diets by dairy cows between diets with high and low ruminal undegradable protein.

ALAWA *et al.*[2] observed that lactating beef cows consumed more barley straw when supplements provided more ruminal degradable protein. In their case, N supply might not satisfy the requirement for the microbes when straw was supplemented with protein of low degradability.

The results suggest that protein supplements increase voluntary intake of silages, while there is little difference between supplements with different ruminal degradability.

Summary

Effect was studied of ruminal degradability of protein supplements on voluntary intake of grass or corn silage by sheep. Each silage was ad libitum offered to sheep alone or supplemented with soybean meal (higher degradability) or corn gluten meal (lower degradability). When given alone, the voluntary intake was 53.4 and 50.3 g DM/kg body weight$^{0.75}$ for grass and corn silage, respectively. Either supplementation increased the intakes of total DM ($P<0.01$) and of each silage ($P<0.05$), but there was little difference between supplements ($P>0.05$).

Literature Listed

1) AGRICULTURAL RESEARCH COUNCIL: The Nutrient Requirements of Ruminant Livestock. 120-181. Commonwealth Agricultural Bureaux, Slough. 1984
2) ALAWA, J. P., FISHWICK, G., PARKINS, J. J. and HEMINGWAY, R. G.: A note on the effect of dietary protein degradability in the rumen on the voluntary intake and digestibility of barley straw by lactating beef cows. *Anim. Prod.*, **44**: 446-449. 1987
3) AOAC: Official Methods of Analysis. 11th ed. 121-131. Association of Official Agricultural Chemists. Washington, D. C. 1970
4) CAMPLING, R. C.: The intake of hay and silage by cows. *J. Br. Grassld. Soc.*, **21**: 41-48. 1966
5) DEMARQUILLY, C.: Composition chimique, Caractéristiques fermentares, digestibilité et quantité ingéré des ensilages de fourrages: Modifications par rapport au fourrage vert initial. *Ann. Zootech.*, **22**: 1-35. 1973 (see *Nutr. Abstr. Rev.*, **44**: No. 4146. 1974)
6) DESWYSEN, A., VANBELLE, M. and FOCANT, M.: The effect of silage chop length on the voluntary intake and rumination behavior of sheep. *J. Br. Grassld. Soc.*, **33**: 107-115. 1978
7) DONALDSON, E. and EDWARDS, R. A.: Feeding value of silage. Silage made from freshly cut grass, wilted grass and formic acid treated wilted grass. *J. Sci. Food Agric.*, **27**: 536-544. 1976
8) FARHAN, S. M. A. and THOMAS, P. C.: The effect of partial neutralization of formic acid silages with sodium bicarbonate on their voluntary intake by cattle and sheep. *J. Br. Grassld. Soc.*, **33**: 151-158. 1978
9) FORBES, T. J. and IRWIN, J. H. D.: The use of barn-dried hay and silage in fattening beef cattle. *J. Br. Grassld. Soc.*, **23**: 299-305. 1968
10) GARNSWORTHY, P. C. and JONES, G. P.: The influence of body condition at calving and dietary protein supply on voluntary food intake and performance in dairy cows. *Anim. Prod.*, **44**: 347-353. 1987
11) GOERING, H. K. and VAN SOEST, P. J.: Forage Fiber Analysis (apparatus, reagents, procedures and some applications). Agric. Handbook No. 379. U. S.

Dep. Agric. Washington, D. C. 1970

12) GILL, M. and ENGLAND, P.: The effect of level of fish meal and sucrose supplementation on the voluntary intake of silage and live-weight gain in young cattle. *Anim. Prod.*, **36**: 513. 1983

13) GILL, M. and ENGLAND, P.: Effect of degradability of protein supplements on voluntary intake and nitrogen retention in young cattle fed grass silage. *Anim. Prod.*, **39**: 31–36. 1984.

14) HUTCHINSON, K. J. and WILKINS, R. J.: The voluntary intake of silage by sheep. 2. The effect of acetate on silage intake. *J. agric. Sci., Camb.*, **77**: 539–543. 1971

15) LIU, J. X., KONDO, S., SEKINE, J., OKUBO, M. and ASAHIDA, Y.: The nutritive value of grass, corn and rice silages fed to sheep at different level. *J. Fac. Agr. Hokkaido Univ.*, **63**(1): 125–135. 1986

16) LIU, J. X., OKUBO, M., KONDO, S., SEKINE, J. and ASAHIDA, Y.: Effects of ruminal degradability of protein supplements on nutrients digestion and nitrogen utilization in lambs fed grass or corn silage. *J. Fac. Agr. Hokkaido Univ.*, **63** (3): 293–299. 1987

17) MERTENS, D. R.: Application of theoretical mathematical models to cell wall digestion and forage intake in ruminants. Ph. D. Dissertation. Cornell Univ. Ithaca. N. Y. 1973

18) MORGAN, C. A., EDWARDS, R. A. and MCDONALD, P.: Intake and metabolism studies with fresh and wilted silages. *J. agric. Sci., Camb.*, **94**: 287–298. 1980

19) PHILLIP, L. E., BUCHANAN-SMITH, J. G. and GROVUM, W. J.: Effect of ensiling whole plant corn on voluntary intake, rumen fermentation, retention time and rate of digestion in steers. *J. Anim. Sci.*, **51**: 1003–1010. 1980

20) STEEL, R. G. D. and TORRIE, J. H.: Principles and Procedures of Statistics. 194–231. 305–331. McGraw-Hill Book Co., New York. 1960

21) THOMAS, C., GILL, M. and AUSTIN, A. R.: The effect of supplements of fish meal and lactic acid on voluntary intake of silage by calves. *Grass Forage Sci.* **35**: 275–279. 1980

22) WALDO, D. R., MILLER, R. W., OKAMOTO, M. and MOORE, L. A.: Ruminant utilization of silage in relation to hay, pellets and hay plus grain. I. Composition, digestion, nitrogen balance, intake and growth. *J. Dairy Sci.*, **48**: 910–916. 1965

23) WILKINS, R. J.: The nutritive value of silages. *in* Recent Developments in Ruminant Nutrition. (HARESIGN, W. and COLE, D. J. A., eds.) 268–282. Butterworths. London. 1981

24) WILKINSON, J. M., PENNING, I. M. and OSBOURN, D. F.: Effect of stage of harvest and fineness of chopping on voluntary intake and digestibility of maize silage by young beef cattle. *Anim. Prod.*, **26**: 143–150. 1978