Influence of Roughage Level on Soybean Meal Degradation and Microbial Protein Synthesis in the Rumen

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Story in Brief

Four dairy steers (500 lb) fitted with ruminal and duodenal cannulas were fed a concentrate or roughage based diet with or without added soybean meal (SBM) to determine the influence of roughage level on escape of SBM protein from ruminal degradation. Efficiency of microbial protein synthesis was 19 percent greater with the high roughage diet. However, since organic matter digestion in the rumen was 18 percent lower with the high roughage diet, the amount of microbial nitrogen synthesized in the rumen was not greatly affected by diet. Ruminal and total tract digestion of starch was not affected by diet. Escape of SBM protein from ruminal degradation was 48 percent greater on the high concentrate diet. In cases where concentrate and roughage are fed at different times, as commonly practiced when feeding dairy cattle, feeding a SBM supplement with the concentrate portion of the diet may enhance bypass to the small intestine.

Introduction

Previous efforts to increase the supply of supplemental protein to the small intestine of ruminants have focused on alteration of the protein source to decrease its ruminal degradability. Chemical and heat treatment have received the most attention. The influence of diet on ruminal protein degradation has received less attention. Disappearance of SBM protein from dacron bags has been shown to be greater with roughage than concentrate fed steers. Measurement of SBM protein bypass obtained with cannulated steers fed concentrate or roughage diets in different studies, suggested that bypass was lower when fed with roughage rations (Zinn and Owens, 1982). The objective of this study was to assess the effect of roughage level on ruminal degradability of supplemental SBM protein and efficiency of microbial protein synthesis, both of which can influence the supply of amino acids reaching the small intestine.

Materials and Methods

Digestion of protein from dacron bags was studied using three Hereford steers (1400 lb) equipped with ruminal cannulas. Each animal received a diet of roughage (83 percent chopped prairie hay, 15.5 percent SBM and 1.5 per-

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cent minerals), concentrate (62 percent corn, 14 percent cottonseed hulls, 10 percent SBM, six percent ground alfalfa hay, six percent molasses and two percent minerals and vitamins) or a mixture of the two. All diets contained 12.5 percent crude protein. Dacron bags containing either SBM or meat meal (MM) were suspended in the rumen of each animal for 12 and 24 hr, removed, washed, dried and analyzed for loss of nitrogen (N).

To examine effects in animals, four dairy steers (500 lb) equipped with ruminal and duodenal cannulas were fed a concentrate (C) or roughage (R) based diet with or without SBM (Table 1) in a 4 x 4 latin square. Urea was added to the diets not supplemented with SBM to avoid deficiency of ruminal ammonia. Chromic oxide was included as an indigestible marker. Animals were fed every 12 hr at a daily level equal to 1.6 percent of body weight.

After five days of feeding, fecal and duodenal samples were collected twice daily (am and pm) for three days. Feed was sampled prior to each sampling day. Samples from each animal were composited for each period, dried in a 60 C oven for 48 hr and ground for analysis of organic matter, nitrogen, starch and total purines, an index of microbial protein.

On the fourth day of sampling, rumen fluid was collected (am and pm) for ammonia and pH measurements and determination of purine to nitrogen ratio in isolated bacteria.

Results and Discussion

Disapperance of SBM N from dacron bags placed in the rumen for 12 or 24 hr was observed much greater with steers fed roughage, least with con-

Table 1. Ration composition

Item	Diets			
	C	CSBM	H	HSBM
	---------- % of diet DM ----------			
Rolled corn	82.1	61.6	41.5	22.3
Chopped prairie hay	8.1	7.9	48.3	48.0
Soybean meal	0	21.2	0	20.9
Supplement	9.8	9.3	10.2	8.8
Urea	.60	0	.51	0
Cottonseed hulls	5.16	5.21	5.68	4.93
Chromic oxide	.25	.25	.25	.24
Dicalcium phosphate	1.23	1.24	1.22	1.17
Limestone	.47	.48	.47	.45
Vitamin A	.01	.01	.01	.01
Vitamin D	.002	.002	.002	.002
TM salt	.50	.50	.49	.48
$NaSO_4$	.50	.50	.49	.48
KCl	.58	.58	.57	.55
Molasses	.50	.51	.50	.48
Crude protein, % of DM	10.3	17.3	8.4	15.2

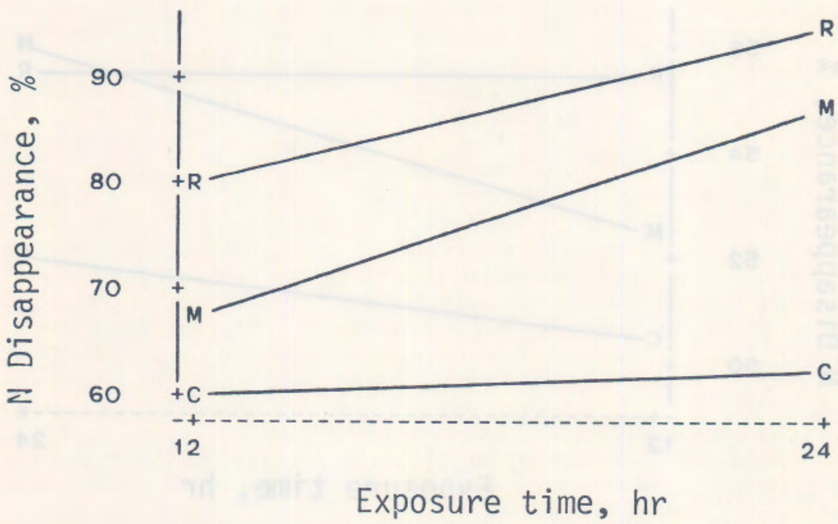

Figure 1. Disappearance of SBM from bags

R = Roughage diet
M = Mixed diet
C = Concentrate diet

centrate fed steers and intermediate with steers receiving a mixed diet (Figure 1). Though disappearance ranked similarly with the three diets for meat meal (Figure 2), differences were very small. Ruminal pH's on the R, M and C diets were 6.7, 6.5 and 6.4, respectively. Since SBM, a vegetable protein source, contains cellulose, microbial degradation of soybean protein may be limited by fiber barriers. Since ruminal fiber digestion is more extensive when higher roughage levels are fed, this may account for the greater SBM disappearance with the steers fed roughage. Since meat meal contains no fiber, no effect of roughage level on protein digestion would be expected.

Based on this information, the effect of roughage level on ruminal degradability of SBM was measured in steers. A concentrate diet with (CSBM) or without (C) supplemental SBM and a hay based diet with (HSBM) or without (H) supplemental SBM were used (Table 1). Hay feeding resulted in a higher ruminal pH, while microbial proteolysis and deamination of supplemental SBM produced higher ruminal ammonia-N levels (Table 2).

Organic matter (OM) digestion, both in the rumen and total tract (Table 3) was less on the higher roughage diets. However, the portion of the total tract OM digestion occurring in the rumen was similar for all diets, with the exception of the unsupplemented hay diet (H). The depression observed in the rumen on this diet may be due to an ammonia deficiency in the rumen as ammonia concentration was only 2.4 mg/dl. Total liquid flow at the duodenum was greater with steers fed the higher roughage diets, paralleling greater salivation.

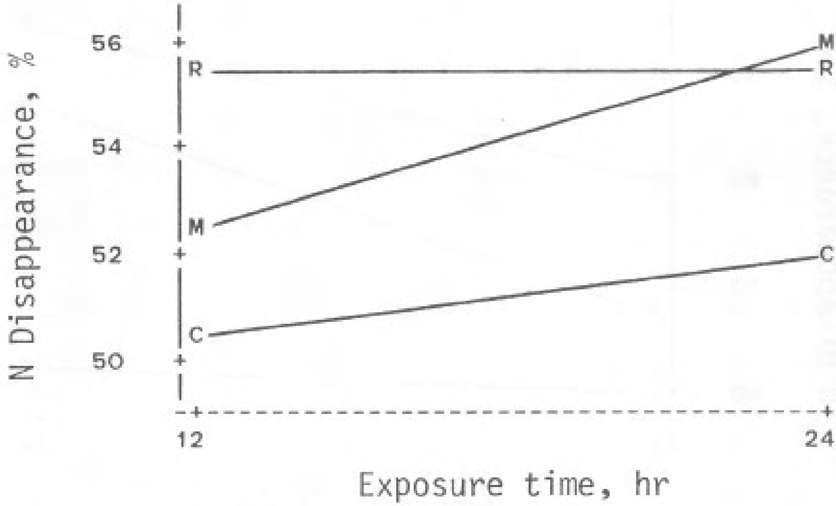

Figure 2. Disapperance of meat meal from bags

R = Roughage diet
M = Mixed diet
C = Concentrate diet

Table 2. Ruminal parameters

Item	Diets			
	C	CSBM	H	HSBM
Ammonia-N, mg/dl	5.6[c]	18.9[a]	2.4[c]	12.8[b]
pH	6.55[c]	6.44[c]	6.93[a]	6.77[b]

[abc]Means in a row with different superscripts differ statistically ($P < .05$).

The lower digestibility of N in the rumen and total tract with the unsupplemented diets (C and H) (Table 4) is predominantly the result of lower N intakes on these diets. Unaccounted endogenous N losses comprise a larger portion of the undigested N flow on diets low in protein, resulting in lower estimated digestibility of feed nitrogen. The negative ruminal N digestibility on diet H was a result of greater N leaving than being consumed. This commonly is observed with low N diets, due to the recycling of N to the rumen. However, microbial N synthesis on diet H was not as great as observed on the other diets, likely due to a combination of lower ruminal N availability and decreased ruminal OM digestion. Efficiency of microbial N synthesized per unit of OM digested in the rumen was greater with the higher roughage diets. Longer retention of OM in the rumen as well as decreased total ruminal OM digestion, coupled with a greater ruminal liquid dilution rate would support an increased efficiency of microbial protein synthesis.

Table 3. Organic matter

Item	Diets			
	C	CSBM	H	HSBM
Intake	3410	3403	3397	3410
Leaving abomasum, g/day				
Total	1307[b]	1231[b]	1861[a]	1435[b]
Non-microbial	1017[bc]	882[c]	1621[a]	1191[b]
Chyme, liter/day	25.7[c]	26.7[c]	39.9[a]	34.8[b]
Ruminal digestion				
% unadjusted	61.7[a]	63.7[a]	45.3[b]	58.1[a]
% adjusted[e]	70.2[ab]	73.9[a]	52.4[c]	65.3[b]
Ruminal digestion, % of total	78.0[ab]	75.1[ab]	65.8[b]	79.0[a]
Feces, g/day	705[c]	516[d]	1068[a]	909[b]
Post ruminal digestion, % of entering	45.2[b]	58.0[a]	41.1[b]	36.4[b]
Total tract digestion, %	79.3[b]	84.9[a]	68.6[d]	73.4[c]

[abcd]Means in a row with different superscripts differ statistically ($P < .05$).
[e]Adjusted for microbial organic matter.

Table 4. Nitrogen

Item	Diets			
	C	CSBM	H	HSBM
Intake, g/day	59[c]	100[a]	49[d]	90[b]
Leaving abomasum, g/day				
Total N	53[b]	61[ab]	57[ab]	62[a]
Microbial N	23[ab]	25[a]	21[b]	23[ab]
Non-ammonia, non-microbial	27[b]	32[ab]	33[ab]	35[a]
Ruminal digestion, %				
% unadjusted	10.2[b]	38.9[a]	-15.6[c]	30.7[a]
% adjusted[e]	53.7[b]	67.3[a]	33.0[c]	61.6[a]
Microbial efficiency				
g microbial N/kg OM truly digested in rumen	9.6[b]	9.9[ab]	12.8[a]	10.5[ab]
Ruminal digestion, % of total	15.2[b]	48.2[a]	-29.3[c]	41.1[a]
Feces, g/day	20[bc]	19[c]	22[ab]	23[a]
Postruminal digestion, % of entering	61.9[b]	68.4[a]	61.4[b]	63.1[b]
Total tract digestion, %	66.0[c]	80.8[a]	55.3[d]	74.7[b]

[abcd]Means in a row with different superscripts differ statistically ($P < .05$).
[e]Adjusted for microbial and ammonia nitrogen.

Table 5. Starch

Item	Diets			
	C	CSBM	H	HSBM
Intake, g/day	2148[a]	1679[b]	1136[c]	679[d]
Leaving abomasum, g/day	374[a]	319[a]	279[a]	131[b]
Apparent ruminal digestion, %	82.7	80.9	75.5	80.7
Ruminal digestion, % of total	88.6	83.5	83.0	85.4
Feces, g/day	140[a]	54[b]	98[ab]	37[b]
Postruminal digestion, % of entering	58.8	84.0	60.4	70.4
Total tract digestion, %	93.5[ab]	96.9[a]	91.3[b]	94.5[ab]

[abcd]Means in a row with different superscripts differ statistically ($P < .05$).

Diet had little effect on ruminal or total tract digestion of starch (Table 5). Diet effects on fiber digestibility in the rumen remain to be determined.

Escape of SBM protein from ruminal degradation was 20.4 percent with the high concentrate diet and 13.8 percent with the high roughage diet. This calculation assumes a ruminal degradability of 40 percent for the corn that replaced the SBM in the unsupplemented diets. As the earlier dacron bag results suggested, greater cellulolytic activity in the rumen of roughage fed animals may degrade more of the SBM cellulose matrix, exposing more protein for microbial attack. All bypass values seem low, possibly due to the low intake level and high ruminal pH.

Including roughage in the diet decreased OM digestion in the rumen but had little influence on microbial N reaching the small intestine due to increased efficiency of microbial N synthesis. Since more SBM protein escaped ruminal degradation with the high concentrate diet, feeding of supplemental protein with the concentrate portion of the feeding scheme may result in more bypass of SBM protein.

Literature Cited

Zinn, R. A. and F. N. Owens. 1982. Okla. Agr. Exp. Sta. Res. Rep. MP-112:216.