INFLUENCE OF HEAT TREATMENT OF SOYBEAN MEAL ON RUMINAL NITROGEN ESCAPE AND UTILIZATION BY LACTATING DAIRY COWS

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Story In Brief

Diets containing either commercial soybean meal or soybean meal which had been heat treated were fed to five lactating dairy cows with duodenal T-type cannulas to estimate the amount of feed nitrogen which escaped ruminal degradation under typical production conditions. Diet dry matter consisted of 60 percent concentrate, 12 percent prairie hay and 28 percent sorghum silage formulated to provide 0.76 Mcal NE_l/lb. Protein from soybean meal accounted for 61 percent of the total protein intake. Nitrogen solubilities of commercial and extra-heat soybean meal were 19.3 and 11.2 percent of total nitrogen. Digestibilities of dietary organic matter were similar in the rumen (55.0 versus 52.5), post-ruminally (37.1 versus 37.6) and in the total tract (72.4 versus 71.5 percent) for diets containing the two meals. Dry matter intake, milk yield, chemical composition of milk, and total nitrogen, microbial nitrogen and ammonia nitrogen entering the duodenum also were similar. Of the total feed nitrogen, slightly more escaped ruminal degradation for the extra-heat than the commercial soybean meal diet (58.1 versus 56.1 percent). If one attributes the difference in escape of total nitrogen in the diet to the soybean meal alone, escape calculates to be increased by 2.6 percent due to heat treatment. The extra heating of soybean meal did not significantly increase ruminal escape of feed protein or milk production of lactating cows.

(Key Words: Soybean Meal, Rumen, Nitrogen Escape, Processing.)

Introduction

Providing the protein is digestible in the small intestine and the amino acid composition is balanced, the value of dietary protein to ruminants is influenced largely by the proportion of the protein which escapes ruminal degradation. Modifying proteins to increase their resistance to microbial attack and loss in the rumen has been of commercial interest. Heat treatment may increase ruminal escape. Heat-treated proteins that are relatively resistant to ruminal degradation yet available in the small intestine have proven useful in diets for young growing ruminants and high producing dairy cows (Netemeyer et al., 1982). Factors such as heating time, temperature and flow rate are important to optimize the conditions for ruminal protection. A poor combination of these factors may overprotect a protein so that it is neither fermented in the rumen nor digested in the small intestine.

The objective of our study was to measure ruminal escape of feed nitrogen in diets containing regular and heat-treated soybean meal.

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Materials and Methods

Soybean meals, prepared by the flash desolventizing system and classified according to protein dispersibility index (PDI), were obtained from a commercial manufacturer. PDI, a measurement of the degree of heat treatment, was 10 for the heat-treated soybean meal (HSBM) and 40 for the regular soybean meal (SBM). Both were fed in a ruminal nitrogen escape study to measure the amount of feed nitrogen that escaped degradation in the rumen. Diets were formulated to provide 0.76 Mcal net energy for lactation (NE_l) per lb of dry matter (Table 1). Soybean meals comprised 31 percent of the total concentrate mixture used in the study and protein from SBM accounted for 61 percent of the total protein intake. Diets were formulated to meet National Research Council (NRC, 1978) feeding standards. Diet dry matter consisted of 60 percent grain mix, 28 percent sorghum silage and 12 percent prairie hay.

Prior to initiation of the study, five mature cows (four Holstein and one Ayrshire) weighing approximately 1203 lb were fitted with T-type cannulas in the duodenum proximal to the bile duct. These lactating cows were used to estimate the amount of feed nitrogen which escaped ruminal degradation. After calving, cows were adjusted to diets with a 60:40 concentrate to forage ratio and were continued on diets with this percentage of concentrates throughout the study from week 4 to 22 of lactation.

Cows were fed in individual stalls three times daily (0300, 1100, 1900 hours) and feed weights were recorded daily. Cows were fed the test diets 2 wk prior to each two 4-day sampling period. Duodenal and fecal samples were obtained at 0300, 1100 and 1900 hours on day 4 through day 7 of each sampling period. During each period, ruminal fluid was collected from a ruminally cannulated cow fed each experimental diet for isolation of ruminal bacteria. Samples of the concentrate mixtures, sorghum silage, sudangrass hay and refused feed were collected each week and analyzed for dry matter, protein, ash and

Table 1. Ingredient composition and characteristics of diet dry matter.

Item	Treatment	
	SBM	HSBM
Ingredients, %		
Corn, ground	36.57	36.57
Soybean meal (PDI-40)	19.2	0
Soybean meal (PDI-10)	0	19.2
Molasses, cane	3.0	3.0
Dicalcium phosphate	.6	.6
Limestone	.6	.6
Salt, trace mineralized	.03	.03
Sorghum silage	28.0	28.0
Prairie hay	12.0	12.0
Protein, % of DM	17.6	17.6
Solubility of SBM-N in .15 M NaCl	19.3	11.2
NE_l (Mcal/lb of DM), calculated	.76	.76

chromium. Milk yields were recorded twice daily at 0700 and 1900 hours. Milk samples were collected for four consecutive milkings each week, composited, and analyzed for milk fat and total protein. Lyophilized bacteria and dried duodenal samples were analyzed for nucleic acid-N which was used as a microbial marker. Daily amounts of feed DM and N flowing past the duodenal cannula were calculated by subtracting the microbial contribution from the total DM and non-ammonia N flows.

Results and Discussion

Results of this experiment were presented previously (Ward et al., 1982). More details are provided in this report and more values regarding ruminal escape of feed protein have been calculated. Dry matter intake averaged about 45 lb/day but was not significantly affected by diet (Table 2). Body weight gain tended to be somewhat higher with the HSBM than the SBM diet. Production of fat corrected milk was almost identical for cows fed the two diets.

Ruminal organic matter (OM) digestion, unadjusted or adjusted for microbial OM, for the two diets was similar (Table 3). The proportion of organic matter digestion occurring in the rumen was slightly lower for the heat treated diet than the regular soybean meal diet (74.5 vs 76.3 percent). Extent of post-ruminal digestion and total tract organic matter digestion were similar (37.6 vs 37.1 percent and 71.5 vs 72.4 percent, respectively). Apparent and true OM digestibilities indicated that diets were fermented to similar extents in the rumen.

Nitrogen intake, flows and digestibilities were determined based on chromic oxide as an indigestible flow marker. Amounts of total N, microbial N and ammonia entering the duodenum were similar for both treatments (Table 4). Feed nitrogen escaping ruminal degradation was slightly higher for HSBM than the SBM diet (336 vs 327 g/day, respectively). Assuming other diet ingredients were equally degraded in the two diets, and non-ammonia, non-microbial N flow was increased

Table 2. Responses of cows fed regular and heat treated soybean meal.

Item	Treatment	
	SBM	HSBM
Number of measurements	10	10
Feed intake		
Dry matter, lb/day	44.5	44.9
Total protein, lb/day	7.9	7.9
Protein, % of DM	17.8	17.6
Weight change, lb/day	0.11	0.25
Milk, lb/day	54.8	55.0
Fat, %	3.15	3.15
Protein, %	3.16	3.16
FCM[a], lb/day	47.1	47.4
Milk/feed DM	1.23	1.23

[a]FCM = 0.4 (milk/day) + 15 (lb fat/day).

Table 3. Organic matter digestion in cows fed regular and heat treated soybean meal.

Item	Treatment	
	SBM	HSBM
Organic matter flow, g/day		
Intake	18784	18966
Duodenal		
Total	8405	8832
Non-microbial	7243	7643
Fecal	5188	5337
Organic matter digestion, %		
Rumen		
Unadjusted	55.0	53.3
Adjusted	61.4	59.7
Of total tract	76.3	74.5
Postruminal		
Of diet	17.4	18.2
Of duodenal flow	37.1	37.6
Total tract	72.4	71.5

Table 4. Nitrogen (N) digestion in cows fed regular and heat treated soybean meal.

Item	Treatment	
	SBM	HSBM
Intake, g/d		
Total	578	577
Soybean meal N	353	352
Leaving abomasum, g/d		
Total N	453.2	467.6
Microbial N	99.8	102.9
Ammonia	26.4	28.7
Non-ammonia, non-microbial	327.0	336.0
Feces, g/d	166.8	172.9
Feed N bypass, %	56.1	58.1
Ruminal digestion, %		
Unadjusted	21.8	18.7
Adjusted[a]	34.7	31.8
Microbial efficiency, g		
Microbial N/kg OM truly digested in rumen	14.1	13.5
Ruminal digestion, % of total	30.2	26.7
Post-ruminal digestion, % of input	62.7	62.1
Total tract digestion, %[b]	71.3	69.8
Expected total digestion[b], %	73.2	73.0

[a]Adjusted for microbial and ammonia nitrogen.
[b]Calculated as: % digestible protein = [.9 (% crude protein)-3]/% crude protein.

by 9 g daily from the 352 g of N from soybean meal. Hence, SBM N escape was increased by 2.6 percentage units by heat treatment. This change is very small. Fecal nitrogen was 6.1 g greater with the HSBM than the SBM diet making total tract digestibility slightly lower with HSBM than for SBM. Microbial efficiency, g of microbial N/kg OM truly digested in the rumen, 13.5 and 14.1 for the two groups, was not affected by soybean meal treatment but was lower than most reported values.

None of the nitrogen and organic matter parameters measured were significantly altered by heat treatment of SBM. The percentage of ruminal escape of total feed nitrogen was only slightly higher in cows fed extra heat SBM compared to the control group (58.1 vs 56.1 percent). Hence, the extra heating applied in processing of the soybean meal available for this trial appeared to be ineffective in protecting soybean meal from ruminal degradation. More extensive heating of whole soybeans or SBM has been shown to increase escape of SBM protein in other trials (Plegge et al., 1985; Stern et al., 1985). Availability of N in the small intestine was not measured directly, but total postruminal digestion was not reduced greatly. Variation in processing methods may be responsible for this difference.

Based on these data and those of a previous continuous feeding trial, heat treatment of soybean meal did not markedly increase the amount of feed protein escaping ruminal degradation. The escape values obtained with lactating cows consuming a 60 percent concentrate ration at high levels of intake are higher than commonly reported. Ruminal escape of soybean protein must have been near 50 percent to achieve the duodenal N flow values attained. The high concentrate level may be partly responsible for the high escape value as indicated by Ward et al. (1986).

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