SUBSTITUTION OF CORN GLUTEN MEAL FOR SOYBEAN MEAL IN RANGE SUPPLEMENTS ON INTAKE AND UTILIZATION OF LOW QUALITY NATIVE GRASS HAY BY BEEF STEERS

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Story in Brief

Five supplements containing blends of soybean meal and corn gluten meal were fed to cannulated (rumen, duodenum, ileum) beef steers to determine the effect of substituting ruminal escape protein for ruminal degradable protein on intake and utilization of low quality native grass hay (5.1% CP, 74.6% NDF). Supplements were formulated to supply 1.0 lb of supplemental crude protein in proportions of 100:0, 75:25, 50:50, 25:75 and 0:100 soybean meal:corn gluten meal on a protein basis. Hay organic matter intake decreased linearly from 25.3 lb/day for steers receiving 100% soybean meal to 21.7 lb/day for steers receiving 100% corn gluten meal. Corn gluten meal supplementation decreased organic matter flow to the duodenum, ileum and feces although organic matter digestibility at these sites was not altered. Digestible organic matter intake decreased linearly with increased proportions of corn gluten meal in the supplement. Duodenal nonammonia nitrogen flow peaked with 25% corn gluten meal but declined with further substitutions. Mean ruminal ammonia concentrations decreased from 1.08 to .26 mg/dl and hay disappearance from nylon bags decreased from 42.9 to 34.6% as supplemental corn gluten meal increased. This study suggests that the substitution of corn gluten meal for soybean meal in range supplements supplying 1.0 lb of supplemental protein decreases intake and utilization of hay and the flow of nitrogen to the small intestine. Consequently, ruminal escape protein should be added to range supplements only after ruminal degradable protein requirements have been met.

(Key Words: Beef Steers, Grass Hay, Soybean Meal, Corn Gluten Meal, Intake, Site of Digestion.)

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Introduction

Beef cattle placed on dormant native grass pastures during the winter must receive supplemental protein to maintain performance. Traditionally, protein supplements are composed of soybean meal or cottonseed meal. These feeds are classified as ruminal degradable protein sources because most of their protein is degraded by microbial fermentation in the rumen. The major role of these protein sources is to supply ruminal ammonia to stimulate microbial activity to improve forage utilization and supply microbial protein for the cattle.

When beef cows are lactating, ruminal bacteria may not be capable of synthesizing enough protein to satisfy the protein requirement of the cow (NRC, 1985). Under these circumstances, protein sources that escape ruminal degradation can be used to supply additional protein to the small intestine. Recent evidence suggests that the use of escape protein in range supplements for lactating beef cows may improve cattle performance (Hibberd et al., 1988).

Because adequate ruminal ammonia concentrations are essential for forage utilization, feeding excess ruminal escape protein could limit ruminal ammonia concentrations and subsequent microbial activity. The level of supplemental ruminal escape protein that elicits this response is unknown. Consequently, the objective of this study was to evaluate the effect of substituting a ruminal escape protein source (corn gluten meal) for a ruminal degradable protein source (soybean meal) on intake and utilization of low quality native grass hay by mature beef steers.

Materials and Methods

Five mature Hereford steers (avg. weight 1,334 lb) were individually penned and fed coarsely chopped (2-inch) native grass hay (5.1% CP, 74.6% NDF). Steers were fitted with a ruminal cannulae and T-type cannulae in the proximal duodenum and terminal ileum. Five supplements were formulated to supply differing ratios of ruminal degradable to ruminal escape protein (Table 1). Corn gluten meal was substituted for soybean meal on a protein basis so that the proportion of supplemental protein from corn gluten meal increased linearly (0, 25, 50, 75 or 100% corn gluten meal protein). Minerals were added to supply adequate levels of calcium, phosphorus and salt. Sulfur was added to maintain a 12:1 supplemental nitrogen:sulfur ratio. Supplements were fed once daily (8:00 a.m.) and fresh hay was offered immediately after supplement consumption.

Treatments (supplements) were applied in a 5 x 5 Latin square design. Five 14-day periods consisted of eight days of adaptation and six days of sampling. Hay intake was measured on days 9 through 12. Duodenal, ileal and

Table 1. Composition and nutrient supply of supplements fed to beef steers consuming low quality native grass hay.

	Supplemental protein blend[a]				
Soybean meal, %	100	75	50	25	0
Corn gluten meal, %	0	25	50	75	100
Supplement composition, % (DM basis)					
Soybean meal	91.44	72.73	51.78	27.72	
Corn gluten meal		18.18	38.58	61.96	88.89
Mineral mix[a]	8.56	9.09	9.64	10.33	11.11
Nutrient supply, lb/day					
Feeding rate[b]	2.22	2.09	1.97	1.84	1.71
Crude protein[b]	1.01	.97	.96	.92	.82
Bypass protein[c]	.28	.34	.40	.44	.47
TDN[c]	.84	.85	.86	.88	.89

[a] Mineral mix contained 61.34% dicalcium phosphate, 29.21% trace mineralized salt, 8.28% sodium sulfate and 1.17% vitamin A premix (30,000 IU/g).
[b] Actual intake.
[c] Estimated intake.

fecal samples were collected six times during days 10 through 12 to represent every 4 h of a 24-h day. Digesta samples were composited by animal and freeze-dried. Digesta, hay and hay refusals were ground through a 1-mm screen prior to laboratory analysis. All samples were analyzed for dry matter, ash and acid insoluble ash. Acid insoluble ash was used as a digesta marker to calculate digesta flow and disappearance through the digestive tract.

Nylon bags containing ground hay were placed in the rumen of each steer on day 11 and incubated for 24 h to measure rate of hay disappearance. Ruminal samples were collected at 0, 1, 2, 3, 4, 5, 6, 9, 12 and 24 h postsupplementation on day 13. Ruminal samples were strained, acidified and frozen. Ruminal ammonia concentrations were determined at a later date.

Data were subjected to least squares analysis with the effects of period, animal and treatment included in the model. Orthogonal polynomials were used to evaluate linear, quadratic and cubic responses to the treatments (supplements).

Results and Discussion

Although supplements were formulated to supply equal quantities of crude protein/day, actual crude protein intake decreased with added corn gluten meal (Table 1). The substitution of corn gluten meal for soybean meal in the supplement decreased hay organic matter (OM) intake linearly (P<.002, Table 2). Although total tract OM digestibility appeared to decrease, the response was not significant (P=.60). Corn gluten meal supplementation decreased OM flow to the duodenum (P<.04) and ileum (P<.10). Because total OM intake decreased in a similar fashion, OM digestibilities at the duodenum and ileum were not affected. Digestible OM intake, however, decreased (linear, P<.001)

Table 2. Effect of supplemental protein source on organic matter (OM) intake and digestion by beef steers fed low quality native grass hay.

	Supplemental protein blend					
Soybean meal, %	100	75	50	25	0	
Corn gluten meal, %	0	25	50	75	100	SE
Intake, lb/day						
Hay OM[a]	25.3	24.8	23.1	23.3	21.7	.72
Total OM[a]	27.3	26.6	24.8	24.9	23.2	.72
Digestible OM[a]	14.2	13.7	12.8	12.8	11.9	.40
Duodenal						
OM flow, lb/day[a]	14.7	15.2	14.2	13.7	13.1	.67
OM digestibility, %	46.1	42.8	42.2	44.8	43.4	1.59
Ileal						
OM flow, lb/day[b]	13.3	12.9	13.1	12.2	11.8	.68
OM digestibility, %	51.4	51.4	46.4	50.7	49.2	2.05
Total tract						
OM flow, lb/day[a]	13.1	12.9	12.0	12.1	11.3	.62
OM digestibility, %	52.1	51.4	51.4	51.3	50.8	1.58
Small intestine digestibility						
OM, % of entering	10.0	15.1	7.3	10.2	9.9	3.65
Large intestine digestibility						
OM, % of entering	1.1	-.2	7.3	1.1	3.4	3.71

[a] Significant linear effect (P<.05).
[b] Significant linear effect (P<.10).

as the proportion of supplemental corn gluten meal increased. Digestible OM intake is reflective of energy intake suggesting that the use of corn gluten meal as a supplemental protein source decreased total energy intake under the conditions of this study.

Total nitrogen intake decreased linearly (P<.05) as the proportion of supplemental corn gluten meal increased (Table 3). Duodenal nonammonia nitrogen (NAN) flow peaked (quadratic, P=.06) with 25% corn gluten meal and declined with additional corn gluten meal. Duodenal NAN flow was positively correlated with nitrogen intake (r=.80). In contrast, duodenal NAN flow was negatively correlated with bypass protein intake (r=-.68). Because duodenal nitrogen flow was not partitioned, the effect of bypass protein intake on nonmicrobial nitrogen flow to the duodenum is unknown. If microbial growth was limited by inadequate ruminal degradable protein, microbial protein flow to the duodenum could have been decreased. Total tract NAN digestibility decreased (linear, P<.05) with added corn gluten meal. A portion of this response may be due to decreased corn gluten meal protein digestibility. Decreased protein intake with added corn gluten meal would also be expected to decrease apparent protein digestibility because of the contribution of metabolic fecal nitrogen.

Mean ruminal ammonia concentrations decreased linearly (P<.003) as corn gluten meal was substituted for soybean meal (Table 3). Ruminal ammonia concentrations peaked at 2 h postsupplementation when 100% soybean meal was fed (Figure 1). Maximum ruminal ammonia concentrations occurred later

Table 3. Effect of supplemental protein source on nitrogen utilization, ruminal ammonia concentrations and nylon bag disappearance in beef steers fed low quality native grass hay.

	Supplemental protein blend					
Soybean meal, %	100	75	50	25	0	
Corn gluten meal, %	0	25	50	75	100	SE
Total N intake, lb/d[b]	.34	.33	.32	.31	.29	.005
Duod NAN[a] flow, lb/d[c]	.39	.42	.40	.37	.35	.016
Fecal NAN flow, lb/d	.20	.20	.20	.20	.19	.010
Total NAN dig, %[b]	42.6	38.1	35.9	35.4	34.6	2.16
Ruminal ammonia, mg/dl[b]	1.08	.69	.63	.41	.26	.162
Nylon bag DM disappearance, %[b]	42.9	37.2	36.1	36.5	34.6	1.88

[a] NAN = Non-ammonia nitrogen.
[b] Significant linear effect (P<.05).
[c] Significant quadratic effect (P=.06).

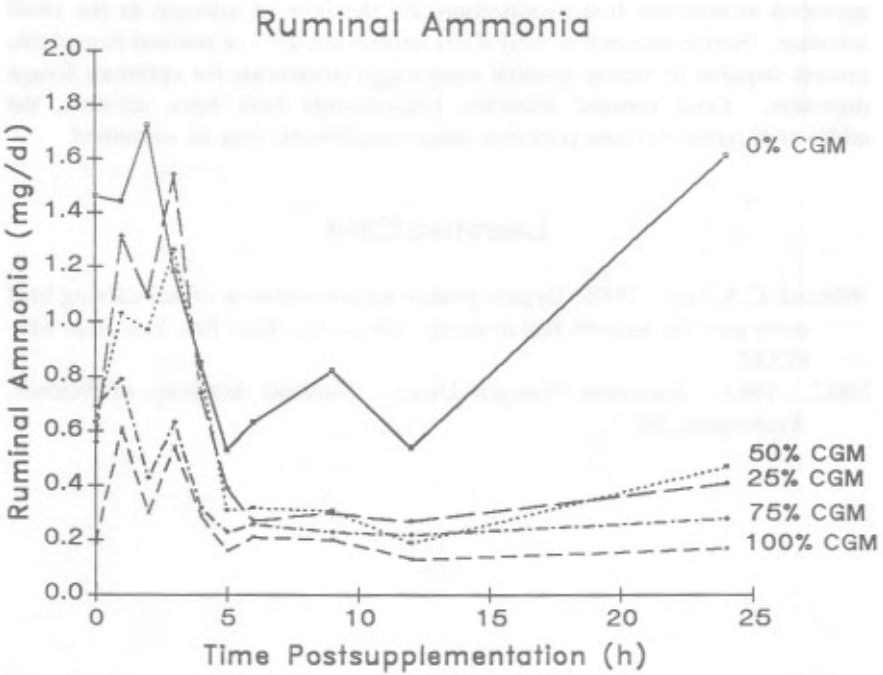

Figure 1. Effect of supplemental protein source on diurnal variation in ruminal ammonia concentrations in beef steers fed low quality native grass hay. Soybean meal was replaced by a proportion of corn gluten meal (CGM) to supply 1.0 lb supplemental crude protein.

(3 h postsupplementation) when the supplement contained 25 or 50% corn gluten meal. Ruminal ammonia concentrations remained below .4 mg/dl for 19 h of the 24-h sampling period when corn gluten meal comprised 25% or more of the supplement. The ruminal protein degradability of corn gluten meal is 35% compared to 72% for soybean meal (NRC, 1985). Inadequate ruminal ammonia concentrations may have limited ruminal microbial activity resulting in reduced digestibility. Decreased disappearance of dry matter (linear, $P<.01$) from nylon bags suspended in the rumen with increased corn gluten meal supports this theory.

Based on the results of previous research (Hibberd et al., 1988), there may be some benefit from adding ruminal escape protein feeds such as corn gluten meal or blood meal to range supplements for lactating beef cows. This study suggests that ruminal escape protein should not be substituted for ruminal degradable protein sources such as soybean meal without considering the supply of ruminal ammonia. In this study, inadequate ruminal degradable protein

appeared to decrease forage utilization and the flow of nitrogen to the small intestine. Further research is needed to establish the level of ruminal degradable protein required to satisfy ruminal ammonia requirements for optimum forage digestion. Once ruminal ammonia requirements have been satisfied, the addition of ruminal escape protein to range supplements may be warranted.

Literature Cited

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