INCREMENTAL LEVELS OF SUPPLEMENTAL RUMINAL DEGRADABLE PROTEIN FOR BEEF COWS FED LOW QUALITY NATIVE GRASS HAY

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Story in Brief

Five mature beef cows fitted with ruminal, duodenal and ileal cannulae were utilized in a 5 x 5 Latin square design to determine the effect of increasing levels of supplemental ruminal degradable protein on hay intake, site of digestion and duodenal nitrogen flow. Cows were fed native grass hay (4% crude protein) ad libitum and blends of soybean hulls and soybean meal to supply graded levels of ruminal degradable protein (.39, .65, .94 and 1.20 lb/day). Ruminal ammonia concentrations increased with added supplemental ruminal degradable protein. Hay organic matter intake peaked with .94 lb/day. In addition, ruminal and total tract organic matter disappearance both peaked with .94 lb/day. Supplement stimulated a linear increase in rate of hay organic matter digestion. Duodenal nitrogen flow increased linearly with supplement and was three-fold higher with 1.20 lb/day compared to the control. This study suggests that ruminal degradable protein exerts a powerful influence on forage utilization and that approximately .94 lb/day supplemental ruminal degradable protein is required to maximize intake and digestion of low quality native grass hay.

(Key Words: Beef Cattle, Grass Hay, Ruminal Degradable Protein, Soybean Meal, Feed Intake, Site of Digestion.)

Introduction

Fall calving beef cows grazing dormant native grass satisfy a large proportion of their energy and protein requirements from fermentation of consumed forage. Microbial fermentation of low quality forage in the rumen is limited by the quantity of ruminal degradable protein supplied in the supplement (Guthrie and Wagner, 1988). In addition to energy, microbial fermentation also

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produces microbial protein which can be used to meet the protein requirement of the cow.

Previous studies have illustrated increased forage digestion with ruminal degradable protein (RDP) supplementation but have not determined the quantity of RDP required to maximize forage utilization. In addition, the effect of RDP supplementation on duodenal nitrogen flow has not been quantified. The objective of this experiment was to determine the effect of increasing levels of supplemental RDP on forage intake, site of organic matter digestion and nitrogen flow to the small intestine.

Materials and Methods

Five mature beef cows (1,186 lb, average weight) fitted with ruminal, duodenal and ileal cannulae were fed native grass hay and graded levels of supplemental RDP. Treatments and cows were arranged in a 5 x 5 Latin square with pen randomized in each period. The native grass hay used in this study was coarsely chopped (2-inch) and contained 4.0% CP, 79.9% NDF and 7.3% lignin. Supplements were composed of blends of soybean meal and soybean hulls (Table 1). Soybean meal (50% CP) and soybean hulls (12% CP) differ markedly in protein concentration but appear to be similar in RDP (72%). Supplemental energy supply was equalized with soybean hulls to prevent confounding effects between supplemental protein and energy levels. Soybean hulls were used to minimize negative associative effects. A control (.24 lb

Table 1. Feed composition of supplements supplying increased quantities of ruminal degradable protein.

		RDP, lb/day[a]			
Feed, % (DM basis)	Control	.39	.65	.94	1.20
Soybean hulls		91.00	62.71	32.49	
Soybean meal			28.04	57.95	90.11
Molasses	35.14	3.00	3.00	3.00	3.00
Dicalcium phosphate	37.27	3.24	3.34	3.46	3.58
TM salt[b]	27.05	2.35	2.43	2.51	2.60
Sodium sulfate		.36	.43	.55	.66
Vitamin A (30,000 IU/g)	.54	.05	.05	.05	.05

[a] RDP=Ruminal degradable protein.

[b] Trace mineralized salt contained 92% NaCl, .25% Mn, .20% Fe, .033% Cu, .007% I, .005% Zn and .0025% Co.

mineral plus .13 lb dried molasses) was used to assess the digestibility of unsupplemented hay. The highest treatment supplied 1.65 lb supplemental protein (Table 2) which provided 140% of the protein requirement of a gestating beef cow and 120% of the protein requirement of a lactating beef cow (NRC, 1984).

Cows were adapted to supplements for two weeks followed by one week of intensive sampling. Supplements were fed once daily at 7:00 a.m. Hay intake was measured on days 16 through 19 as hay offered minus hay refused. Hay refusals were discarded and fresh hay was fed daily. Nutrient intake was calculated by subtracting total nutrients refused from total nutrients offered. Duodenal, ileal and fecal samples were obtained eight times over days 16 through 19 to represent every 3 h of a 24-h day. Acid insoluble ash was determined on hay, hay refusal and digesta samples to calculate nutrient flow and digestibility. Nylon bags containing hay were incubated ruminally to measure rate of organic matter digestion. Ytterbium-labeled hay was fed on day 16 and subsequent timed fecal samples were collected to measure particulate passage rate. Intensive ruminal sampling was performed on day 20 to measure ruminal ammonia concentrations.

Table 2. Nutrient composition and daily nutrient supply of supplements providing increased quantities of ruminal degradable protein.

		RDP, lb/day[a]			
	Control	.39	.65	.94	1.20
Nutrient, % DM					
Crude protein[b]	3.0	12.9	22.1	33.1	43.4
TDN[c]	22.2	71.0	73.4	75.8	78.4
Calcium[c]	12.64	1.19	1.17	1.15	1.13
Phosphorus[c]	11.09	.82	.98	1.14	1.32
Feeding rate, lb DM/day	.34	4.17	4.07	3.95	3.84
Nutrient supply, lb DM/day					
Crude protein					
Total[b]	.01	.54	.90	1.31	1.66
RDP[ac]	.01	.39	.65	.94	1.20
TDN[c]	.08	2.99	3.00	3.00	3.00

[a] RDP=Ruminal degradable protein.
[b] Actual analysis.
[c] Estimated.

All data were subjected to least squares analysis with a model that included period, animal and treatment. Orthogonal contrasts were used to compare the control vs all supplements plus the linear, quadratic, and cubic response to level of supplemental ruminal degradable protein.

Results and Discussion

Ruminal ammonia concentrations showed a time x treatment interaction ($P<.0001$) which suggests that treatment differences were dependent on sampling time (Figure 1). Ruminal ammonia concentrations peaked at 2 h after supplementation and increased linearly ($P<.0001$) with added RDP supplementation. Ruminal ammonia concentrations remained below 1 mg/dl for the control and .39 lb RDP treatments for most of the day. When .94 or 1.20 lb RDP were fed, ruminal ammonia concentrations were sustained above 2 mg/dl for most of the day. Ammonia is a primary end product of ruminal protein degradation and should be elevated when ruminal degradable protein sources such as soybean meal are fed.

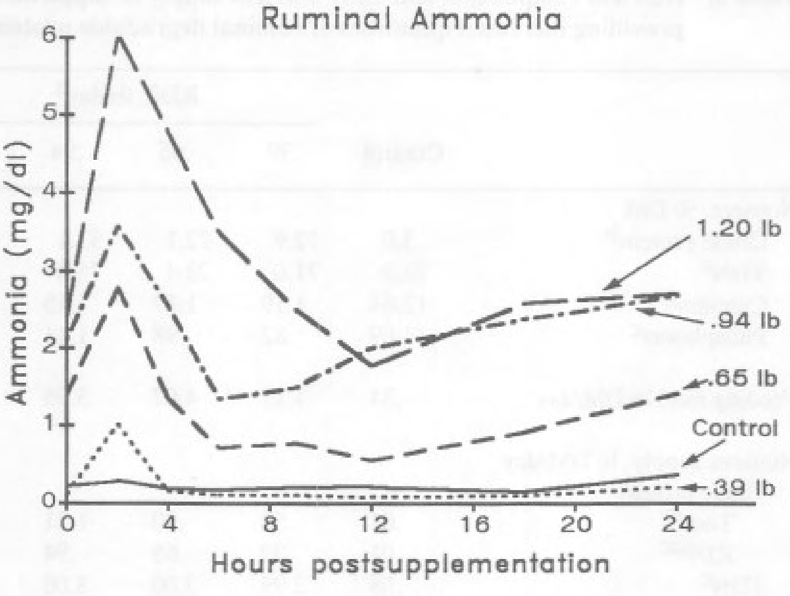

Figure 1. Diurnal changes in ruminal ammonia concentrations in beef cows fed low quality native grass hay supplemented with graded levels of ruminal degradable protein.

Supplementation increased (P<.001) hay and total organic matter (OM) intake (Table 3). Hay OM intake increased from 11.6 lb/day with .39 lb RDP to 15.8 lb/day with 1.20 lb RDP. Hay OM intake peaked (quadratic, P=.08), however, with .94 lb RDP (16.6 lb hay OM/day). Total OM intake followed a similar trend. Unlike previous studies (Guthrie and Wagner, 1988), supplemental RDP in this study was increased to the point that hay OM intake was maximized.

Total tract OM digestibility was 46.6% for unsupplemented hay and was increased (P<.001) with RDP supplementation (Table 3). Total tract OM digestibility increased linearly (P<.05) with added supplemental RDP. Total tract OM disappearance peaked (quadratic, P<.10) with .94 lb supplemental RDP. Increased hay OM intake (quadratic, P<.10) coupled with increased total tract OM digestibility (linear, P<.05) to improve total tract OM disappearance. Because total tract OM disappearance is indicative of energy intake, cows supplemented with .94 lb RDP should have maximized daily energy consumption.

Supplemental RDP increased (P<.001) OM disappearance in the rumen compared to the control (Table 3). Ruminal OM disappearance peaked (quadratic, P<.10) with .94 lb supplemental RDP. Maximal ruminal OM disappearance matched the peak in hay OM intake. In addition, the largest proportion of OM disappearance (84 to 92% of total OM disappearance) occurred in the rumen. Supplemental RDP did not affect uncorrected ruminal OM digestibility. Rate of hay OM digestion, measured with nylon bags, was increased (P<.001) with supplementation. Supplemental RDP increased rate of hay OM digestion linearly (P<.0001). Supplemental RDP supplies ammonia (Figure 1) which would be expected to stimulate ruminal microbial activity and increase forage fermentation. Supplemental RDP also increased particulate passage rates (linear, P<.01) which may have increased particulate flow to the extent that OM digestibility was not altered.

Organic matter disappearance in the small and large intestines was small compared to ruminal OM disappearance (Table 3). Because the native grass hay utilized in this study was composed primarily of cell wall (79.9% NDF), ruminal fermentation of fiber was essential to diet utilization. Consequently, most of the residual forage flowing to the lower tract may have been largely undigestible fiber components. Thus, most of the OM disappearing in the small intestine was probably microbial cells produced in the rumen.

Duodenal N flow was increased (linear, P<.001) with added supplemental RDP (Table 4). Duodenal N flow, however, tended to peak with .94 lb RDP (quadratic, P<.12). Duodenal N flow was three-fold higher with 1.20 lb supplemental RDP compared to the control. Supplemental RDP should increase ruminal microbial growth and subsequent protein flow to the duodenum. A portion of the nitrogen reaching the duodenum could be undegraded hay and soybean meal/hull nitrogen. Even with 1.20 lb supplemental RDP, however,

Table 3. Effect of ruminal degradable protein supplementation on intake and digestion of organic matter by beef cows fed low-quality native grass hay.

		RDP, lb/day[a]				
	Control	.39	.65	.94	1.20	SE
Organic matter intake, lb/day						
Hay[cd]	8.4	11.6	14.0	16.6	15.8	.84
Total[cd]	8.5	15.3	17.6	20.0	19.1	.84
Organic matter disappearance[b]						
Rumen						
lb/day[cd]	3.7	7.5	8.6	10.0	9.3	.43
Mouth to duodenum, %[c]	43.3	49.4	49.0	50.5	48.8	1.30
Small intestine						
lb/day[ce]	.2	.3	1.0	.9	1.6	.19
Duodenum to ileum, %[e]	8.7	4.0	17.2	12.6	25.5	3.38
Mouth to ileum, %[ce]	46.2	50.8	54.8	55.0	57.1	2.04
Large intestine						
lb/day[c]	.1	.6	.3	.6	.3	.16
Ileum to anus, %[c]	.4	7.8	3.4	6.6	3.6	2.16
Total tract						
lb/day[cd]	4.0	8.4	9.9	11.6	11.1	.46
Mouth to anus, %[ce]	46.6	54.9	56.5	58.1	58.6	1.33
OM digestion rate, %/h[ce]	2.75	2.92	3.38	3.73	4.73	.188
Particulate passage, %/h[ce]	.80	1.64	2.36	2.19	2.54	.213

[a] RDP=Ruminal degradable protein.
[b] Uncorrected for microbial organic matter.
[c] Control vs all RDP supplements (P<.005).
[d] Quadratic response to increased supplemental RDP (P<.10).
[e] Linear response to increased supplemental RDP (P<.05).

dietary N flow to the duodenum would not be expected to exceed .12 lb/day. Consequently, most of the nitrogen flowing to the duodenum is probably in the form of microbial N.

This study illustrates that supplemental RDP exerts a powerful influence on intake and utilization of low quality native grass hay. As much as .94 lb of supplemental RDP was required to maximize forage intake and digestion. This

Table 4. Effect of ruminal degradable protein supplementation on nitrogen intake and flow to the duodenum.

		RDP, lb/day[a]				
	Control	.39	.65	.94	1.20	SE
Nitrogen intake, lb/day						
Total[bc]	.06	.16	.24	.32	.37	.006
Hay[bcd]	.05	.08	.09	.11	.11	.006
Supplement[bc]	.00	.08	.14	.21	.27	.003
Duodenal N flow, lb/day[bcd]	.12	.23	.30	.36	.37	.015

[a] RDP=Ruminal degradable protein.
[b] Control vs all RDP supplements (P<.001).
[c] Linear response to increased supplemental RDP (P<.005).
[d] Quadratic response to increased supplemental RDP (P<.12).

level of RDP corresponds to 1.28 lb supplemental protein or 2.56 lb soybean meal. When combined with hay protein intake, total daily protein intake was 2.31 lb/day. This level is 36% higher than the protein requirement for a 1,200 lb gestating beef cow and 10% above the protein requirement for a 1,200 lb lactating beef cow (NRC, 1984). Consequently, protein supplementation based on NRC requirements may not maximize intake and utilization of low quality native grass.

Literature Cited

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