EFFECT OF SUPPLEMENTAL BYPASS PROTEIN ON INTAKE, DIGESTION AND DUODENAL PROTEIN FLOW OF LOW QUALITY NATIVE GRASS HAY IN BEEF COWS

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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 supplemental bypass protein on hay intake, site of digestion and duodenal crude protein flow. Cows were fed native grass hay (4.3% crude protein) free choice and blends of soybean hulls and soybean meal with or without bypass protein. Blood meal and corn gluten meal were used as the bypass protein feedstuffs. Supplements provided two levels of total protein (.9 or 1.3 pounds per day) and two levels of bypass protein (28% or 50% of total protein). Ruminal ammonia concentrations decreased when bypass protein composed 50% of the supplemental protein. Ruminal organic matter disappearance (percent of organic matter intake) was depressed relative to the unsupplemented control and was not affected by level or source of supplemental protein. Level of protein increased hay organic matter and digestible organic matter intakes. Bypass protein did not affect site or extent of digestion. Duodenal crude protein flow increased with added supplemental protein, but did not differ between levels of bypass protein. This study suggests that a blend of blood meal and corn gluten meal may be used in formulating low-starch/digestible fiber supplements for low quality forage diets without decreasing forage utilization, digestible organic matter intake or duodenal crude protein flow.

(Key Words: Beef Cattle, Grass Hay, Bypass Protein, Intake, Digestibility.)

Introduction

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Introduction

Fermentation of forage by ruminants yields microbial protein and volatile fatty acids. Microbial protein flowing to the small intestine supplies a portion of the protein requirement of ruminants. Fall calving beef cows grazing dormant native grass cannot satisfy their protein and energy requirements solely from fermentation of consumed forage. Although, supplemental protein increases forage fermentability (Scott and Hibberd, 1990), duodenal protein flow may still be inadequate. Under these circumstances, feed protein that escapes ruminal degradation (bypass protein) may supplement microbial protein flowing to the small intestine. Excess bypass protein, however, may limit forage utilization (Hibberd and Martin, 1990).

Previous studies have illustrated that bypass protein can replace a portion of the ruminally degradable protein fraction of supplements. Hibberd et al. (1988) increased performance of fall calving cows with supplements containing bypass protein. Cows receiving supplements containing .7 lb bypass protein lost less weight and produced more milk than cows supplemented with .4 lb bypass protein. Supplementation effects on forage utilization and intake, however, were not reported.

Scott and Hibberd (1990) fed increasing quantities of supplemental ruminal degradable protein (RDP) and determined that .9 lb supplemental RDP (1.3 lb total CP) maximized utilization and intake of low quality forage by mature beef cows. In addition, supplemental ruminal degradable protein increased ruminal ammonia concentrations and rate of digestion. Supplemental ruminal degradable protein was required at a rate of .65 lb/day (.9 lb total CP) to maintain ruminal ammonia concentrations above 1 mg/dl. If bypass protein can replace a portion of the ruminal degradable protein fraction of supplements without adversely affecting forage utilization, duodenal N and amino acid flows may be manipulated. The objective of this experiment was to determine the effect of supplementing low quality grass hay diets with two levels of total protein with or without bypass protein on forage intake, site of organic matter digestion and nitrogen flow to the small intestine.

Materials and Methods

Five mature beef cows (1,120 lb, average empty body weight) fitted with ruminal, duodenal and ileal cannulae were fed coarsely chopped (2-inch screen) native grass hay (4.3% CP, 75.2% NDF) and supplements containing two levels of total protein (.9 lb and 1.3 lb) and two levels of bypass protein (28% or 50% of total protein). The fifth treatment was an unsupplemented control which was included to estimate the nutritional value of the native grass hay. Treatments and cows were arranged in a 5 x 5 latin square with pen randomized in each period. Supplements were formulated with 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 ruminal protein degradability (72%). A blend of blood meal and corn gluten meal was added to formulate the 50% bypass supplements. Blood meal (82% bypass CP) and corn gluten meal (55% bypass CP) were utilized because of their complementary amino acid profiles (NRC, 1985). Supplemental energy supply was equalized with soybean hulls to prevent confounding effects between supplemental protein and energy and to minimize negative associative effects (Table 2). All supplements provided 2.9 lb TDN and were fed at a rate of 4.0 lb DM/day. Scott and Hibberd (1990) illustrated that .9 lb RDP (1.3 lb CP) maximized digestion and intake of low quality hay. In this study, the 1.3 lb CP-28% bypass treatment is identical to the .9 lb RDP supplement formulated by Scott and Hibberd (1990).

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 sampled and discarded and fresh hay was fed daily. Nutrient intake was calculated by subtracting total nutrients refused from

Table 1. Feed composition of supplements with differing levels and sources of protein.

		.9 lb CP		1.3 lb CP	
Feed, % (DM basis)	Control	28% BP[a]	50% BP	28% BP	50% BP
Soybean hulls		60.20	71.34	31.36	47.99
Soybean meal		29.40	4.14	58.07	20.36
Blood meal			7.30		10.90
Corn gluten meal			6.71		10.01
Molasses	35.13	4.00	4.00	4.00	4.00
Dicalcium phosphate	37.27	3.44	3.44	3.44	3.44
TM salt[b]	27.05	2.50	2.50	2.50	2.50
Sodium sulfate		.38	.49	.55	.71
Vitamin A (30,000 IU/g)	.54	.05	.05	.05	.05
Dairy flavors	.03	.03	.03	.03	.03

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

Table 2. Nutrient composition and daily nutrient supply of supplements providing differing levels and sources of protein.

		.9 lb CP		1.3 lb CP	
Item	Control	28% BP[a]	50% BP	28% BP	50% BP
Nutrient, % DM					
Crude protein[b]	3.0	22.2	22.2	33.3	33.3
TDN[c]	22.2	73.9	72.0	75.8	72.9
Calcium[c]	12.64	1.37	1.37	1.37	1.37
Phosphorus[c]	11.09	.90	.90	1.14	.99
Feeding rate, lb DM/day	.34	3.95	3.95	3.95	3.95
Nutrient supply, lb DM/day					
Crude protein					
Total[b]	.02	.92	.89	1.33	1.32
RDP[cd]	.01	.66	.45	.96	.66
Bypass[ac]	.01	.26	.44	.37	.66
TDN[c]	.08	2.93	2.85	3.00	2.89

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

total nutrients offered. Duodenal, ileal and fecal samples were obtained eight times over days 16 through 19 to represent every three hours of a 24 hour day. Acid insoluble ash was determined on hay, hay refusal and digesta samples to calculate nutrient flow and digestibility. Ruminal OM digestion was not corrected for contribution of microbial OM. Intensive ruminal sampling was performed on day 20 to measure ruminal ammonia concentrations.

All data were subjected to least squares analysis with a model that included period, animal and treatment. One cow, which became ill during period three, was replaced during subsequent periods and her data for period three was deleted. Orthogonal contrasts were used to compare the control vs all supplements, level of protein, level of bypass protein and protein level by bypass protein level interaction.

Results and Discussion

Treatment differences in ruminal ammonia concentrations were dependent on sampling time (time x treatment, P<.0001; Figure 1). Ruminal ammonia concentrations peaked two hours after supplementation and were higher (P<.0001) with 1.3 lb protein. Fifty percent bypass protein supplements reduced (P<.0001) concentrations of ruminal ammonia, verifying that the 28% bypass supplements supplied more ruminal degradable protein (RDP). Ruminal ammonia concentration of the control was below 1 mg/dl throughout the day. This response illustrates the low nitrogen content of mature grass hay and the need for supplemental protein. Ruminal ammonia concentrations remained below 1 mg/dl for the .9 lb CP supplements for most (18 hours) of the day. Ruminal ammonia concentrations of 1.3 lb CP-28% bypass supplement remained above 1.2 mg/dl for the entire day. The .9 lb CP-28% bypass and 1.3 lb CP-50% bypass supplements supplied the same quantity of RDP, however, ruminal ammonia concentrations of 1.3 lb CP-50% bypass supplement were higher.

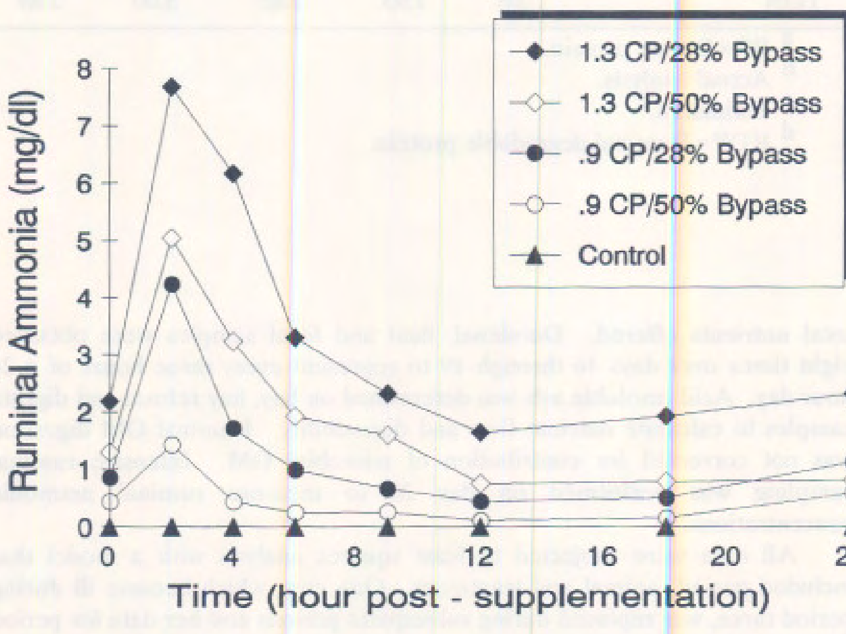

Figure 1. Diurnal changes in ruminal ammonia concentrations in beef cows fed low quality native grass hay supplemented with differing levels and sources of protein.

Higher ruminal ammonia concentrations of the 1.3 lb-50% bypass supplement may be the result of nitrogen recycling. Alternately, faster incorporation of feed protein into microbial protein may have reduced ruminal ammonia concentrations for .9 lb CP-28% bypass supplement. Ruminal pH values (Table 3) support the latter explanation, because rapid fermentation will decrease ruminal pH. Ruminal pH of the control was higher ($P<.0001$) than for protein supplements. Relatively high ruminal pH (6.61) coupled with low ruminal ammonia indicates a slow fermentation rate (Scott and Hibberd, 1990). Level of protein tended to decrease ($P<.07$) ruminal pH. Greater quantities of RDP in 28% bypass supplements may have stimulated fermentation rate and decreased ($P<.001$) ruminal pH compared to 50% bypass supplements.

Supplementation increased ($P<.0001$) hay organic matter (OM) and total OM intake (Table 3). Hay OM intake increased ($P<.01$) from 16.4 lb/day with .9 lb CP to 18.4 lb/day with 1.3 lb CP supplements. Bypass protein did not affect hay OM intake at either level of protein intake. Although 1.3 lb CP (.9 lb RDP) maximized the intake of low quality grass hay (Scott and Hibberd, 1990), these data suggest that bypass protein can supply 50% of total supplemental protein without decreasing hay intake.

Total tract OM digestibility was 58.7% for unsupplemented hay and increased ($P<.003$) with protein supplementation (Table 3). Level of supplemental protein did not affect ($P=.70$) total tract OM digestibility (%). High RDP supplements (28% bypass protein), however, tended ($P=.27$) to increase total tract digestibility. Total tract OM disappearance (digestible OM intake) increased (1.2 lb; $P<.003$) with 1.3 lb supplemental protein. These data are in agreement with Scott and Hibberd (1990) indicating that digestible organic matter intake of low quality hay diets is dependant upon the level of supplemental protein.

Ruminal OM digestion data have not been corrected for microbial OM (Table 3). Ruminal OM digestibility tended to decrease with supplementation. Longer ruminal retention time of unsupplemented forage for the control probably allowed more extensive microbial attack. Supplementation increased ($P<.0001$) the quantity of OM that disappeared in the rumen. Level of supplemental protein increased ($P=.012$) ruminal OM disappearance. Differences in ruminal OM disappearance are mainly due to differences in hay OM intake. The lack of treatment differences in ruminal OM digestibility (%) is probably the result of faster particulate passage rates (Scott and Hibberd, 1990). Supplements containing 28% bypass increased ruminal ammonia concentrations, which should stimulate the rate of forage fermentation. Scott and Hibberd (1990) attributed increased ruminal OM disappearance (lb) to increasing ruminal ammonia concentrations with added supplemental RDP. Although 28% bypass supplements increased ruminal ammonia concentrations, the quantity and

Table 3. Effect of supplemental level and source of protein and undegraded protein on intake and digestion of organic matter by beef cows fed low quality native grass hay.

		.9 lb CP		1.3 lb CP		
	Control	28% BP[a]	50% BP	28% BP	50% BP	SE[b]
Organic matter intake, lb/day						
Hay[de]	11.8	15.9	16.9	18.5	18.3	.71
Total[de]	12.0	19.4	20.4	22.0	21.8	.71
Site of organic matter disappearance[c]						
Rumen						
lb/day[de]	6.5	10.0	10.3	11.3	11.1	.42
Mouth to duodenum, %	54.8	52.1	51.2	52.4	51.9	1.79
Total tract						
lb/day[de]	7.0	12.0	12.3	13.7	13.3	.40
Mouth to anus, %[d]	58.7	62.7	61.2	63.0	61.8	1.28
Ruminal pH[fg]	6.61	6.26	6.39	6.24	6.35	.023

[a] BP = Bypass protein.
[b] Standard error of the mean.
[c] Uncorrected for microbial organic matter.
[d] Control vs all supplements ($P < .001$).
[e] Response to level of supplemental CP ($P < .01$).
[f] Response to level of supplemental CP ($P < .07$).
[g] Response to supplemental bypass protein ($P < .001$).

percentage of ruminal OM disappearance were similar (P>.10) between levels of bypass protein.

Supplemental protein increased (P<.0001) hay CP intake, total CP intake and duodenal CP flow above the control (Table 4). Compared to the control, duodenal CP flow was increased by 2.5 and 3-fold for the .9 and 1.3 lb protein supplements, respectively. The 1.3 lb protein supplements increased (P<.02) duodenal CP flow 24% above .9 lb protein supplements. Supplemental RDP should increase ruminal microbial growth and protein flow to the duodenum. Duodenal CP flow averaged 1.9 lb and 2.35 lb CP/day for the .9 lb and 1.3 lb levels of protein, respectively. Duodenal protein flows for .9 lb and 1.3 lb CP levels are 16% and 11% above the protein requirements for a 1,200 lb gestating or lactating beef cow (NRC, 1984), respectively. Bypass protein did not alter (P=.86) duodenal CP flow. Similar duodenal protein flows between levels of bypass protein may explain the lack of an intake response to bypass protein.

Supplemental protein increased (P<.0001) digestible OM intake (total tract OM disappearance, lb/d) compared to the control. Digestible OM intake was not affected (P=.89) by level of bypass protein. Level of protein further increased (P<.003) intake of digestible OM by 1.2 lb. Approximately one lb of TDN is required per 5 lb increase in milk production (NRC, 1984). Therefore, the high CP supplement should support 5 lb more milk per day than the low CP supplement. In addition, milk production should be stimulated by enhanced duodenal protein flow. Although duodenal protein

Table 4. Effect of supplemental level and source of protein on crude protein intake and flow to the duodenum.

		.9 lb CP		1.3 lb CP		
	Control	28% BP[a]	50% BP	28% BP	50% BP	SE[b]
CP intake, lb/day						
Total[cd]	.5	1.6	1.6	2.1	2.1	.04
Hay[cd]	.5	.7	.7	.8	.8	.04
Supplement[cd]	.0	.9	.9	1.3	1.3	.02
Duodenal CP flow						
lb/day[cd]	.8	1.9	1.9	2.3	2.4	.12

[a] BP=Bypass protein.
[b] Standard error of the mean.
[c] Control vs all supplements (P<.0001).
[d] Response to level of supplemental CP (P<.02).

flow was not affected by level of bypass, duodenal amino acid supply may have been altered by high bypass supplements. Altered duodenal amino acid flow may explain increased milk production of cows supplemented with bypass protein (Hibberd et al., 1988).

This study emphasizes the dramatic positive associative effect that supplemental protein has on the intake and utilization of low quality native grass hay. Increasing the quantity of supplemental CP from .9 to 1.3 lb/day increased CP and TDN intake by .52 and 1.2 lb/day, respectively. These additional nutrients should decrease body weight and condition losses while improving milk production of lactating cows grazing dormant native grass. In addition, bypass protein did not adversely affect digestible OM intake or duodenal CP flow. Consequently, bypass protein sources can be added to range supplements when economically justified.

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