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C.A. Bandyk

R.C. Cochran

T.A. Wickersham

See next page for additional authors

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Effect of ruminal versus postruminal administration of degradable protein on utilization of low-quality forage by beef steers

Abstract

Twelve ruminally fistulated steers were used to evaluate the effects of supplying a highly degradable protein source (casein) both ruminally and postruminally on intake and digestibility of low-quality native hay. Both protein supplementations substantially increased voluntary intake, organic matter digestion, rate of passage, ruminal ammonia, and blood urea concentrations, but intakes were considerably greater when protein was given ruminally as opposed to postruminally.

Keywords

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Authors

C.A. Bandyk, R.C. Cochran, T.A. Wickersham, C.G. Farmer, and Evan C. Titgemeyer

EFFECT OF RUMINAL VERSUS POSTRUMINAL ADMINISTRATION OF DEGRADABLE PROTEIN ON UTILIZATION OF LOW-QUALITY FORAGE BY BEEF STEERS

C. A. Bandyk, R. C. Cochran, T. A. Wickersham, E. C. Titgemeyer, and C. G. Farmer

Summary

Twelve ruminally fistulated steers were used to evaluate the effects of supplying a highly degradable protein source (casein) both ruminally and postruminally on intake and digestibility of low-quality native hay. Both protein supplementations substantially increased voluntary intake, organic matter digestion, rate of passage, ruminal ammonia, and blood urea concentrations, but intakes were considerably greater when protein was given ruminally as opposed to postruminally.

(Key Words: Intake, Degradable Protein, Low-Quality Forage.)

Introduction

Protein supplementation stimulates forage intake, digestion, and performance in animals fed low-quality roughage. Because an inadequate nitrogen supply in the rumen limits microbial growth and, therefore, limits ruminal fermentation and outflow, responses to supplemental protein often are attributed to its ability to satisfy microbial nitrogen requirements. Degradable intake protein (DIP) (protein that is broken down in the rumen) can meet these requirements directly. Because the resulting increase in microbial growth leads to more microbial protein passing to the small intestine, increased DIP intake is associated with increased postruminal protein supply to the host animal.

By-pass, or undegradable intake protein (UIP), provides a direct postruminal supply of protein. UIP also can contribute to meeting the rumen microbial nitrogen need by recycling nitrogen back to the rumen as urea. Although recycling is often very important in maintaining adequate N status in ruminants, it seems unlikely that using UIP to correct a ruminal nitrogen deficiency (via recycling) will be as effective as using DIP per se to directly correct the deficiency. To evaluate that concept, we designed an experiment in which supplemental DIP or UIP was simulated by placing protein directly into different segments of the digestive tract and the effects of these treatments on intake, digestion, and ruminal fermentation were monitored.

Experimental Procedures

Twelve ruminally fistulated steers (average weight, 1239 lbs) were assigned randomly to one of three treatments: control (hay only) or hay plus ruminal or postruminal infusion of 400 g of casein/day. Casein is a high-quality protein source that is degraded readily in the rumen. The experiment had five time periods: 1) 10-day adaptation to the hay diet; 2) 7-day measurement of voluntary intake (hay only); 3) 10-day adaptation to protein treatments (intake measurements continued); 4) 7-day measurement of hay intake and digestibility; 5) 3-day ruminal sampling period. The animals were housed in individual tie stalls and given continuous access to a low-quality, tallgrass-prairie hay (3.4% CP and 76.6% NDF). Orts were removed and measured daily, and fresh hay was offered at 130% of the previous 5-day average intake. Beginning in period 3, casein was administered just prior to feeding, either directly into the rumen or solubilized and infused through lines anchored in the abomasum. Fecal grab samples were collected daily during period 4 and analyzed for acid detergent insoluble ash, which served as an internal marker to determine total fecal output. Feed offered, feed refused, and fecal output were used to calculate voluntary intake, organic matter digestion (OMD), and neutral detergent fiber digestion (NDFD). During period 5, various fill, passage, and fermentation characteristics were measured.

Results and Discussion

Protein supplementation by either route increased hay and total organic matter (OM) intake (P#.01) and OM digestion (P=.04) relative to controls (Table 1). Placing supplemental protein directly into the rumen (P=.04) increased hay intake more than postruminal supplementation (P=.04). In addition, the steers took longer (P=.02) to increase their intake when given their supplement postruminally. These steers also stopped responding sooner after their initial response, but their rate of increase during the period of positive response was similar to that seen with ruminal supplementation (P=.32). The larger intake response for ruminal than postruminal supplementation was accompanied by higher ruminal ammonia levels and an increased passage rate (P<.01). In conclusion, when cattle are consuming low-quality, nitrogen-deficient forages, providing a source of ruminally degradable protein is more effective in stimulating forage utilization than providing ruminally undegradable (by-pass) protein.

Table 1. Effect of Ruminal or Postruminal Casein Infusion on Voluntary Intake and Digestion in Steers Fed Low-Quality, Tallgrass-Prairie Hay

	Treatment				Contrasts[1]	
Item	Control	Post-ruminal	Ruminal	SEM	S vs. None	P vs. R
Hay intake, g/kg MBW[2]	47.8	61.0	77.4	4.85	< .01	.04
Total intake, g/kg MBW[3]	47.8	64.4	80.7	4.89	.01	.05
Intake change, g/kg MBW[4]	-6.8	10.1	24.6	1.97	< .01	.03
Days to intake increase[5]	NA	4.3	1.0	.53	NA	.02
Rate of intake increase[6]	NA	2.3	2.7	.24	NA	.32
OM digestion, %	39.5	47.0	44.7	2.10	.04	.42
NDF digestion, %	39.8	44.9	42.1	3.69	.18	.35

[1]S vs. None = supplemented vs. control, P vs. R = postruminal vs. ruminal infusion.

[2]Hay organic matter intake expressed as grams per kilogram of metabolic body weight (MBW).

[3]Total organic matter intake (hay + supplement) expressed as grams per kilogram of metabolic body weight (MBW).

[4]Change in hay intake from period 2 (period without supplementation) to period 4 (period when supplements were being given). Units are in grams per kilogram of metabolic body weight (MBW).

[5]Number of days after infusions began before a positive increase in hay intake. NA=not applicable.

[6]Rate at which intake increased (g of total organic matter/kg metabolic body weight/day) once a positive change in intake was observed.

Table 2. Effect of Ruminal or Postruminal Casein Infusion on Ruminal pH, Ammonia, Total Volatile Fatty Acid Concentration, Fill, Passage, and Plasma Urea Nitrogen in Steers Fed Low-Quality, Tallgrass-Prairie Hay

	Treatment				Contrasts[1]	
Item	Control	Post-ruminal	Ruminal	SEM	S vs. None	P vs. R
pH	6.67	6.60	6.50	.13	.42	.54
Ammonia, mM	.55	1.35	4.16	.32	< .01	< .01
Total VFA, mM	70	78	82	6.7	.21	.64
Plasma urea N, mM	.83	2.59	2.05	.49	.05	.48
Dry matter contents, g/kg MBW[2]	114.7	127.4	114.8	6.8	.46	.22
Liquid contents, g/kg MBW[2]	712.4	858.9	762.4	40.3	.08	.12
Liquid dilution rate, %/hr	4.61	4.79	5.34	.71	.62	.60
ADIA[3] passage, %/hr	2.06	2.26	3.36	.13	< .01	< .01

[1]S vs. None = supplemented vs.control, P vs. R = postruminal vs. ruminal infusion.

[2]Units are in grams per kilograms of metabolic body weight (MBW).

[3]ADIA=acid detergent insoluble ash.