ILEAL ANTIBIOTIC ADMINISTRATION AND DIETARY PROTEIN LEVEL FOR BEEF HEIFERS FED ROUGHAGE DIETS

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Story in Brief

Four beef heifers were fed prairie hay diets with a low (L) or a high (H) level of crude protein (9 or 12.5 percent), and received daily doses into the ileum of either antibiotics (A) in salt solution or the salt solution (S) without antibiotics. Antibiotic infusion tended to increase ruminal ammonia-nitrogen concentration with the high protein diet but to decrease it with the low protein diet. Digestion of organic matter, acid detergent fiber and starch in the rumen tended to be lower in animals receiving antibiotics. Passage of nonammonia-N to the duodenum was equal to 128, 142, 92 and 104 percent of N intake for LS, LA, HS and HA treatments indicating that antibiotics tended to increase the amount of recycled N which was utilized in the rumen. Antibiotic infusion tended to speed passage of fluid from the rumen and to increase volume of digesta in the large intestine.

Key Words: Digestion, Antibiotic, Protein Level, Infusion.

Introduction

Gastrointestinal tract fill may limit intake of forage-fed ruminants. Since the rumen represents the major contributing organ to gut fill, signals originating at the rumen may regulate intake of grazing cattle. Removal of feed particles from the rumen, either by digestion or passage, relieves ruminal distention. Since all undigested residues must pass out of the rumen, certain signals originating from digesta in the postruminal tract ultimately could control rumen emptying.

The contribution of fermentation in the hindgut to total digestion has received limited attention. Microbial activity in the cecum and proximal colon may influence both digestion and passage rate and either liberate ammonia for recycling to the rumen or capture ammonia for excretion in feces. With a low protein-high fiber diet such as low quality native range grass, ruminal fermentation becomes quite dependent on N recycling and methods to increase recycling could be useful.

By dosing antibiotic into the end of the small intestine, fermentation in the large intestine should be reduced. This could reduce the demand for ammonia in the large intestine. Postruminal antibiotics would have different effects from fed antibiotics, as dietary antibiotics can have direct effects on microbes in the rumen or may be absorbed and have systemic effects. The antibiotic used in this study was not absorbed so it should have no systemic effects. With coating technology, protected antibiotics could be developed to be released past the rumen. Value and effects of post-ruminal antibiotics with various feeding conditions remain to be determined. This study

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investigated the effects of antibiotic doses into the ileum and of dietary protein level on site of digestion and passage rate in beef heifers fed a roughage diet.

Materials and Methods

Four beef heifers (569 lb) in a Latin square experiment were fed diets shown in Table 1. The unabsorbed antibiotic or the wash salt solution were dosed via cannula at 0600 each day in each of the four 14-day periods. Corn labeled with ytterbium and cobalt EDTA were used to measure ruminal and post-ruminal passage rates. Specific dosing, sampling and analytical procedures were described previously (Goetsch and Owens, 1984).

Table 1. Diet compositions.

	Diet	
Ingredient, % of dry matter	L	H
Chopped prairie hay	81.3	81.3
Ground corn	8.5	----
Cane molasses	.4	.4
Soybean meal	9.0	17.5
Trace mineralized salt	.5	.5
Chromic oxide	.3	.3

Results

Ruminal ammonia-N (NH_3-N) was greater with the high protein diet at 2, 6 ($P<.05$) and 10 h ($P>.05$) after feeding (Table 2). NH_3-N tended to decrease with antibiotic infusion with the L diet, but to increase with the H diet. This could be due either to changes in the extent of ruminal fermentation and ammonia release or capture or to changes in the amount of ammonia recycled to the rumen.

Table 2. Ruminal ammonia-nitrogen concentrations.

Time after feeding, h	Treatment[1]				Diet		Infusion	
	LS	LA	HS	HA	L	H	S	A
2	5.81[a]	5.24[a]	8.85[b]	10.12[b]	5.53[a]	9.48[b]	7.33	7.68
6	2.91[ab]	.86[b]	4.21[a]	5.04[a]	1.89[a]	4.62[b]	3.56	2.95
10	5.20	3.00	4.10	6.99	4.10	5.55	4.65	4.99

[1]Treatments include diet (L = 9% crude protein; H = 12.5% crude protein) and ileal antibiotic infusion (S = none; A = antibiotic).

[a,b]Means in a row within treatment, infusion or diet headings differ ($P<.05$).

Protein level had little effect on extent ruminal digestion of organic matter (OM), but ileal antibiotic infusion tended to depress OM disappearance in the rumen (Table 3). Hindgut OM digestion compensated and tended to be greater with antibiotic addition. Disappearance of OM in the hindgut as a percent of OM exiting the ileum was 20.3, 27.1, 22.2 and 29.5 percent for LS, LA, HS and HA treatments, respectively. Hence, the ileal antibiotic did not reduce hindgut or total tract digestion.

Protein level had little effect on acid detergent fiber (ADF) digestion but antibiotic infusion reduced ($P<.08$) ruminal ADF digestion. Again, postruminal digestion compensated for this difference. Ruminal microbial efficiency tended to increase with antibiotic doses, increasing as ruminal OM fermentation decreased. Ruminal passage of particles was related to microbial efficiency (MOEFF), passage of microbial N through the duodenum, and ruminal OM digestion ($r=.61$, .55 and -.52, respectively).

Increasing the protein level tended to decrease ($P<.08$) ruminal starch digestion in the rumen but to increase starch digestion in the total tract. Such a change in site of digestion should increase energetic efficiency. Ileal infusion of antibiotic had a similar effect on site of starch digestion, reducing ($P<.12$) starch digestion in the rumen and increasing ($P<.06$) starch digestion in the hindgut.

Passage of nonammonia-N to the duodenum was equal to 128, 142, 92 and 104 percent of N intake for LS, LA, HS and HA treatments, respectively. An interaction ($P<.10$) between infusion and diet was observed for small intestinal N disappearance (Table 3) in which antibiotics tended to increase disappearance of N from the small intestine at the low protein level but decrease it with the higher protein diet. Amount of microbial N (MN) in feces, estimated from purine concentration, tended to be greater ($P<.10$) with the lower protein diet and represented 36, 34, 22 and 28 percent of total non-ammonia N in feces for LS, LA, HS and HA diets, respectively. Total tract N digestibility corrected for nondietary N, tended to increase with antibiotic infusion with the higher protein diet. Total tract N digestibility, not corrected for nondietary N, was higher with the higher protein level.

Antibiotic infusion tended to reduce passage rate of fluid from the rumen (Table 4), but ruminal fluid passage rate and ruminal volume were inversely related ($r=-.60$). An interaction between antibiotic infusion and protein level ($P<.19$) on ruminal volume and passage rate of fluid through the hindgut approached significance with antibiotic infusion increasing ruminal volume and decreasing passage rate of fluid from the large intestine only with the higher protein diet. The first kinetic component of passage rate of particles from the rumen (k_1) estimated from ileal samples was reduced ($P<.08$) with antibiotic infusion. An increase in ruminal or hindgut volume with antibiotic infusion cause this difference. Passage rate (k_1) for ruminal particles estimated from samples from the ileum differed from k_1 estimated from fecal samples in this trial, but the two were related ($r=.59$).

Discussion

Since the antibiotic was infused into the small intestine and not into the rumen and this antibiotic is not absorbed, effects on ruminal digestion were surprisingly large. These must be due to alterations hormone levels or in nutrient recycling to the rumen which alter ruminal volume or passage rate through the upper digestive tract. The reduction in ruminal digestion with antibiotic infusion with the 9 percent protein diet may be due to the reduction in ruminal ammonia concentration. Ammonia concentration in the rumen was related to disappearance of N in the rumen (r=.44; P<.09). As level of ruminal ammonia increased even above 5 mg/100 ml, extent of organic matter digestion in the rumen has increased (Weakley and Owens, 1983). Starch and ADF digestion in the hindgut compensated for depressed ruminal digestion suggesting that ammonia concentration limited fermentation in the rumen before it limited fermentation in the large intestine.

Table 3. Digestion measures.

Item	Treatment				Diet[c]		Infusion[c]	
	LS	LA	HS	HA	L	H	S	A
Organic matter digestion, % of intake								
Ruminal, true	53.4	47.6	51.5	49.4	50.5	50.4	52.4	48.5
Small intestinal	4.3	4.3	6.3	3.6	4.3	4.9	5.3	3.9
Hindgut	10.0	14.4	9.5	14.5	12.2	12.0	9.8	14.4
Total	67.7	66.2	67.2	67.4	67.0	67.3	67.5	66.8
Acid detergent fiber digestion, % of intake								
Ruminal	60.1	56.0	60.1	58.3	58.0	59.2	60.1	57.2
Postruminal	1.6	4.2	2.0	4.1	2.9	3.0	1.8	4.2
Total	61.6	60.2	62.1	62.4	60.9	62.3	61.9	61.3
Nitrogen disappearance, % of intake								
Ruminal	58.8	38.9	59.9	58.0	48.9	58.9	59.4	48.6
Small intestinal	9.3	32.5	20.0	17.0				
Hindgut	8.2	1.9	-3.1	5.9	5.1	1.4	2.5	3.9
Total, corrected for nonfeed constituents	76.3	73.4	76.8	80.9				
Total, uncorrected for nonfeed constituents	62.5	59.0	70.0	73.2				
Nitrogen passage to the duodenum, g/day								
Total	79.3	88.0	80.6	91.0	83.6	85.8	79.9	89.5
Microbial	49.9	46.7	41.8	49.8	48.3	45.8	45.9	48.3
Feed	23.7	35.2	32.0	33.5	29.4	32.7	27.8	34.3
Ammonia	5.8	6.1	6.7	7.8	5.9[a]	7.2[b]	6.2	6.9
Microbial efficiency, g microbial nitrogen/kg organic matter fermented	26.3	31.4	23.3	28.7	28.9	26.0	24.8	30.1

Treatments include diet (L = 9% crude protein; H = 12.5% crude protein) and ileal antibiotic infusion (S = none; A = antibiotic).

[ab]Means in a row within treatment, infusion or diet headings with different superscripts differ (P<.05).

[c]Omitted means denote an interaction between infusion and diet (P<.10).

Table 4. Passage of digesta and volume estimates.

Digesta phase	Sampling site	Item	Treatment LS	Treatment LA	Treatment HS	Treatment HA	Diet L	Diet H	Infusion S	Infusion A
Fluid	Rumen	Ruminal passage rate, %/h	6.2	5.6	7.7	5.4	5.9	6.6	7.0	5.4
		Ruminal volume, l	63.8	57.7	47.0	57.5	60.7	52.2	55.4	57.6
	Rectum	Hindgut passage rate, %/h	26.3	25.3	30.0	21.4	25.8	25.7	28.2	23.4
Particulate	Ileum	k_1, %/h	10.2	7.3	10.5	9.4	8.7	10.0	10.3	8.4
		k_2, %/h	2.9	3.1	2.0	2.2	3.0	2.1	2.1	2.7
	Rectum	k_1, %/h	8.2	5.8	5.7	6.3	7.0	6.0	6.9	6.1
		k_2, %/h	2.2	2.7	2.6	2.6	2.5	2.6	2.4	2.7

Treatments include diet (L = 9% crude protein; H = 12.5% crude protein) and ileal antibiotic infusion (S = none; A = antibiotic).

Hindgut starch disappearance increased (r=.66) as ruminal ammonia increased. This relationship between ruminal ammonia and hindgut digestion of starch and fiber is probably due to increased ruminal escape of fermentable substrate and passage to the hindgut for digestion.

Ruminal OM digestion increased as particle passage rate decreased. This suggests that the time needed for particle size reduction probably did not delay passage of particles from the rumen. When particles in the rumen disintegrate slowly, the relationship between ruminal digestion and passage rate will be positive. As passage rate of particles from the rumen (k_2) increased, OM digestion in the total tract decreased (r=-.49; P<.06) as well. With this prairie hay diet, extent of digestion in the rumen and the total tract were both limited by digestion of cell walls which occurs primarily in the rumen.

ADF digestion in the rumen increased as passage rate of particles from the rumen decreased (r=-.38; P<.15). In contrast, ADF digestion decreased as rate of FLUID passage from the rumen decreased (r=.46; P<.07). No explanation for this relationship is apparent. Usually fluid and particle passage rates vary together. Increased rumination should increase both fluid passage and extent of ADF digestion. Possibly changes in the relative volumes of fluid and particles in the rumen or passage of fluid imbibed in undegraded forage particles are responsible. Decreased water intake can increase digestibility of certain forages like wheat pasture.

In this trial, microbial efficiency (MOEFF) increased as passage rate of particles increased. Increased efficiency would be expected when microbes leave the rumen more rapidly since the idling time and energy cost for microbes will decrease. In a previous experiment with concentrate diets (Goetsch and Owens, 1984) no relationship of MOEFF to particle passage rate was detected. The relationship of MOEFF to passage rate may be stronger with roughage than concentrate diets, since 1) with concentrate feeds, less ruminal action is needed to prepare particles for ruminal exit and 2) microbes may associate more intimately with roughage than concentrate particles. Nonammonia-N passage to the duodenum, expressed as a percent of N consumed, was higher for the lower protein diet and increased with antibiotic infusion. This may reflect differences in ruminal ammonia concentration since ammonia absorption from the rumen increases as its concentration increases.

Assuming that ileal digesta contained 10 percent dry matter, hindgut volumes were 12.4, 15.0, 10.6, and 17.0 ml/kg of body weight, representing 4.5, 5.1, 5.3, and 6.9 percent of the estimated ruminal fluid volume for LS, LA, HS and HA treatments, respectively. Thus, large intestinal plus cecal volume increased with antibiotic infusion whether expressed on a body weight basis or relative to ruminal volume. Antibiotic-fed or germ-free nonruminants usually have a larger cecal or large intestinal volume than animals with their normal microbial population in the intestine. Enlargement of the hindgut may be due to presence of undigested osmotic compounds which pull water into the intestine, to entry of greater amounts of digesta or to reduced gut motility or gut wall thickness. The increase in hindgut volume with antibiotic infusion can explain the lower passage rate for fluid through the hindgut.

Results indicate that antibiotic doses into the intestine increases volume of the large intestine. These changes can affect rumen function through altering recycling of N to the rumen and thereby change site of digestion. Hence, interactions between antibiotic effectiveness and protein level and concentrate level should be expected. Additional mechanisms (hormonal, neural) which influence volume of and passage rate from various sections of the digestive tract need further study.

Literature Cited

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