ILEAL ANTIBIOTIC ADMINISTRATION AND DIETARY NITROGEN LEVEL FOR BEEF HEIFERS FED HIGH CONCENTRATE DIETS

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Story in Brief

Effects of daily ileal administration of antibiotics (A) or water solution (S) to beef heifers receiving high concentrate diets containing 10.7 (L) or 13.6 percent (H) crude protein on site of digestion and passage rates were determined. Ileal administration of antibiotics increased ileal pH and tended to decrease ruminal ammonia-nitrogen (NH_3-N) concentrations with the L diet but increased NH_3-N with the H ration. Trends for increased ruminal starch and decreased nitrogen digestibilities for ileal antibiotic administration with both diets were observed. Ruminal particulate passage rate determined from ileal samples was increased with A. Results indicate that postruminal microbial activity can influence digestion in the rumen.

Introduction

Crude protein requirements of finishing cattle over 1000 lb are below 10 percent of dietary dry matter (NRC, 1976). However, crude protein is usually fed in excess of 10 percent of DM due to decreased feed intake and performance at lower protein levels. Finishing diets usually consist of cereal grains fed ad libitum. With milo and corn grains, substantial quantities of starch are not completely fermented in the rumen and become available in the cecum and proximal colon for further microbial fermentation.

Postruminal fermentation may increase the diffusion of urea from blood into the hindgut to supply nitrogen for microbes (Orskov et al., 1970). Nitrogen uptake by microbes and microbial cell excretion in feces lowers apparent nitrogen digestibility. However, urinary nitrogen excretion may decrease to compensate for elevated fecal loss. Besides N flux, the relationships between hindgut fermentation and ruminal digestion remain unclear. The objectives of this experiment were to investigate effects of antibiotic administration at the ileum and dietary nitrogen level on passage rates and site of digestion in heifers fed high concentrate diets.

Experimental Procedure

Four beef heifers (460 lb), fitted with ruminal, duodenal and ileal cannulas, were used in a 4x4 Latin square experiment. Periods lasted 14 days with ruminal, duodenal, ileal and fecal samples being obtained on the last four days of each period. Animals were fed at a level equal to 1.8 percent of body weight (dry matter basis) in two equal feedings at 0800 and 2000 hr. In each of the four periods, two animals received a dose of a nonabsorbable antibiotic mixture into the ileum each day at 0600 hr (A). An additional 25 ml of a .85 percent NaCl was used to cleanse the delivery tube. Animals not receiving antibiotics were

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similarly dosed with 65 ml of .85 percent NaCl solution (S). Diets were 86 percent concentrate, rolled corn based, containing 10.7 (L) and 13.6 percent (H) protein and were formulated to provide substantial quantities of starch entering the hindgut. Soybean meal was substituted for rolled corn to achieve these crude protein levels and chromic oxide was included as an indigestible marker.

A particulate marker (ytterbium labeled ground corn) and a fluid marker (CoEDTA) were used to estimate ruminal dilution rates. In addition, CoEDTA was dosed into the ileum to estimate fluid passage rate through the large intestine. Feed, ruminal, duodenal, ileal and fecal samples were subjected to all or part of the following analyses: pH, dry matter (DM), ash, nitrogen (N), acid detergent fiber (ADF), starch, chromium, nucleic acid-N (NAN), NH_3-N, ytterbium and cobalt.

Results and Discussion

Ruminal, duodenal and rectal digesta pH, averaged over four sampling times, were similar for all treatments (Table 1). However, ileal pH was greater with the A than the S treatment (Table 1). Backflush of antibiotic from the infusion site or inhibition of production of acid by bacteria in this segment of the gut may be responsible. Ruminal NH_3-N concentrations, averaged over four sampling times, were higher for the H diet (Table 1). With the H diet, A heifers had slightly greater ruminal NH_3-N levels. This may be due to a decrease in hindgut microbial fermentation, reducing the N gradient between the gut lumen and the bloodstream or a reduction in the number of urea hydrolyzing bacteria, depressing N cycling to the hindgut. Antibiotic infusion to L heifers tended to decrease ruminal NH_3N levels. Ruminal NH_3-N concentrations are influenced by N influx from the blood, degradation of dietary crude protein, ruminal volume, microbial uptake, and ruminal absorption and outflow. Reduced ruminal degradation of dietary protein with A may be partially responsible for the decrease in ruminal NH_3-N with the L diet.

Ruminal organic matter (OM) and starch digestibilities were similar for all treatments. L heifers had slightly lower ruminal OM digestion coefficients than H animals. Differences may be primarily explained by N digestion. Antibiotics slightly improved ruminal OM and starch

Table 1. Ruminal ammonia concentrations and digesta pH measures.

Item	Treatment				Infusion		Diet	
	SL	SH	AL	AH	S	A	L	H
Ruminal ammonia-nitrogen, mg/dl	1.8^{a}	5.1^{b}	1.2^{a}	6.9^{b}	3.4	4.1	1.5^{a}	6.0^{b}
Ruminal pH	6.0	6.1	6.2	6.2	6.1	6.2	6.1	6.1
Duodenal pH	2.2_{a}	2.2_{ab}	2.2_{b}	2.1_{b}	2.2_{a}	2.1_{b}	2.2	2.2
Ileal pH	6.8^{a}	7.1^{ab}	7.2^{b}	7.2^{b}	7.0^{a}	7.2^{b}	7.0	7.1
Fecal pH	5.6	5.5	5.5	5.6	5.5	5.6	5.5	5.5

^{ab}Means in a row within treatment, infusion or diet headings with different superscripts differ ($P<.05$).

digestion with the L diet. With the H diet, antibiotics tended to increase ruminal starch digestion but caused a small decrease in ruminal OM fermentation. Alteration in ruminal N digestion (Table 2) may be responsible for this latter change. Differences in ruminal starch digestion may have influenced microbial NH_3-N uptake. Ruminal ADF digestion values were similar, paralleling changes in OM digestion. Hindgut OM (Table 2) and starch digestibilities tended to be greater for S than A heifers. SL and AL treatment means were similar while those for AH tended to be lower than for the SH group. Perhaps hindgut digestion in SL heifers was already limited by insufficient N cycling to the hindgut.

Antibiotic dosage caused 27 and 45 percent decreases ($P<.05$) in ruminal N digestion for L and H groups, respectively (Table 2). This may be due to a doubling of ruminal particulate passage rates as determined by ileal sampling (Table 3). Ruminal N digestion and the ileal estimate of ruminal particulate passage rate were related ($r=-.49$; $P<.06$). Hindgut passage rate was related to the rate constant describing the rate of particulate marker appearance at the ileum ($r=.46$; $P<.08$) and the rectum ($r=.40$; $P<.13$). Hence, changes in ruminal N digestion may be influenced by ruminal passage rates that are interacting with digesta kinetics in the hindgut. Similar interrelationships between omasal and abomasal passage rates have been described (Phillipson and Ash, 1965).

The slightly higher ruminal NH_3-N level coupled with the lower N digestibility of AH vs SH animals may be attributable to less N recycling to the hindgut with the administration of antibiotic. In contrast, the AL treatment had slightly lower ruminal NH_3-N concentrations than SL animals, yet ruminal OM digestion was slightly greater. Less depression of ruminal N digestion by antibiotic administration with the L than the H diet may be due to lower baseline NH_3-N levels and greater recalcitrance of corn than soybean meal N.

Trends for lower N digestibility of the H than the L diet may be related to kinetics of ruminal digestion. The passage rate of added soybean meal in the H ration was not measured, but ruminal N digestion was negatively related to the estimated ruminal passage rate of rolled corn as calculated from ileal samples, as mentioned earlier, and from the rectal samples ($r=-.54$; $P<.04$). Due to differences in particle size, hydratability, length of digestion lag time and rate of disintegration, passage of soybean meal from the rumen should have been faster than of rolled corn. Microbial efficiency was slightly decreased by antibiotics with both diets, but all values are higher than expected for high concentrate diets.

Small intestinal digestion of N (Table 2) tended to be greater for A than for S animals (47 percent increase), almost totally compensating for differences in digestion of N in the rumen. Fecal ($P<.05$) and ileal ($P<.05$) microbial N (MN) measures were lower for A heifers than for S animals, while the H group had slightly greater fecal MN passage than the L group (Table 2). Generally, duodenal MN passage paralleled fecal values while ileal measures did not. Hence, differences in fecal MN cannot be explained by passage of undigested MN of ruminal origin. Ileal MN values were much greater than expected, perhaps due to microbial fermentation in the ileum. Lower fecal than ileal MN levels reflects a net loss of nucleic acids between the ileum and rectum, possibly through gross synthesis in the large intestine combined with extensive degradation of ileal nucleic acids. The ratio of NAN to total MN content derived from bacterial cells isolated from ruminal fluid also may not be applicable to bacteria from the hindgut. Nevertheless,

Table 2. Digestion measures.

Item	Treatment				Infusion		Diet	
	SL	SH	AL	AH	S	A	L	H
Organic matter, %								
Ruminal digestion	61.7	58.8	64.7	55.1	60.2	59.9	63.2	57.0
Sm intestional digestion	12.7	7.5	6.0	18.9	10.1	12.4	9.3	13.2
Hindgut digestion	4.9	14.0	4.8	-.4	9.5	2.2	4.9	6.8
Total digestion	79.3	80.2	75.5	73.5	79.7	74.5	77.4	76.9
Starch, %								
Ruminal digestion	70.1	69.1	78.1	73.8	69.6	76.0	74.1	71.4
Sm intestional digestion	14.2	10.0	2.1	14.6	12.1	8.3	8.1	12.2
Hindgut digestion	8.9	11.7	8.7	-1.5	10.3	3.5	8.7	5.1
Total digestion	93.2	90.8	88.8	86.9	92.0	87.8	91.0	88.8
Nitrogen, %								
Ruminal digestion	48.5	47.9	35.4	26.3	48.2[a]	30.9[b]	42.0	37.1
Sm intestional digestion	34.9	25.9	40.5	49.0	30.4	44.7	37.7	37.4
Total digestion, apparent	57.8	63.4	58.8	60.2	60.6	59.5	58.3	61.8
Total digestion, corrected for fecal MN	69.5	74.3	66.9	68.2	71.9	67.5	68.2	71.3
Microbial nitrogen, g/day								
Duodenal	88.1	96.4	81.2	94.1	92.3	87.6	84.7	95.2
Ileal	36.2	37.3	24.4	17.2	36.7[a]	20.8[b]	30.3	27.2
Fecal	16.7	20.0	11.5	14.5	18.4[a]	13.0[b]	14.1	17.3

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

Table 3. Digesta kinetics.

Digesta phase	Sampling site	Item	Treatment				Infusion[d]		Diet[d]	
			SL	HL	AL	AH	S	A	L	H
Fluid	Rumen	Ruminal passage rate, hour^{-1}	.121	.072	.094	.114	--	--	--	--
	Rumen	Ruminal volume, liters	17.2	24.3	29.5	16.4	20.8	22.9	23.4	20.3
	Rectum	Hindgut passage rate, hour^{-1}	.146[a]	.174[ac]	.216[c]	.087[b]	--	--	--	--
Particulate	Ileum	Ruminal passage rate, hour^{-1}	.035	.034	.078	.069	.034[a]	.074[b]	.057	.051
	Rectum	Ruminal passage rate, hour^{-1}	.032	.033	.030	.036	.033	.033	.032	.034

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

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

administration of the antibiotic mix decreased both ileal and fecal passage of MN. Total tract N digestibilities (NDIG) corrected for MN content were greater than uncorrected values. Effects of antibiotics on NDIG were influenced by ruminal N digestibilities. Antibiotics lessened differences between corrected and uncorrected NDIG.

Interactions ($P<.10$) between infusion and diet were observed for ruminal and hindgut fluid passage rates (Table 3). By assuming 10 percent DM in ileal digesta, hindgut fluid volume estimates of 16, 18, 12 and 26 ml/kg body weight are derived, representing 20, 15, 9 and 34 percent of the ruminal fluid volume for SL, HL, AL and AH treatments, respectively. Ruminal fluid volume and passage rate were negatively related ($r=-.60$; $P<.02$). Antibiotics tended to increase ruminal fluid passage rate with the H diet but decreased passage rate with the L diet. Neither ruminal fluid passage rate, ruminal fluid volume or hindgut fluid passage rate were related to digestibility. Treatments which lower ruminal ADF disappearance may increase ruminal fluid passage rate by increasing mastication and saliva flow. However, fiber entering the hindgut may increase gut peristalsis and increase passage rate. But, effects of protein and antibiotics on ruminal ADF digestion were small.

Ruminal particulate passage rates (Table 3) were determined by sampling digesta at the terminal ileum and rectum. Rectal measurements were similar for all treatments. However, ileal values were higher ($P<.05$) for A heifers. This may be attributed to a feedback alteration in passage rates in the intestines via altered gut hormones or microbial end products. Results indicate that microbial activity in the hindgut can influence digestive function in the rumen. Alterations in site of digestion for some nutrients, especially N, and effects of postruminal antibiotics on ruminal dilution rate warrant further research.

Literature Cited

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