ILEAL STARCH ADMINISTRATION AND DIETARY NITROGEN LEVEL FOR STEER CALVES FED HIGH CONCENTRATE DIETS

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Story in Brief

Effects of adding 12 to 13 g starch to the ileum and dietary nitrogen (N) level on passage rates and site of digestion were studied with cannulated steer calves (170 lb) fed high concentrate diets. Animals either received soluble starch (S) or water (C) and were fed 12 (L) or 15 percent (H) crude protein diets. Ileal starch did not alter ruminal ammonia-N concentrations but fluid passage rate from the ileum tended to be greater for the S than for the C treatment. Ruminal organic matter and starch digestibilities were slightly lower for S steers, especially with the H diet. Fecal microbial N (MN) was increased by starch infusion. Rectal passage of microbial N, calculated from nucleic acid passage, was 11, 9, 15 and 17 percent of N intake for CL, CH, SL and SH treatments, respectively, being from 17 to 33 percent of fecal N. Fluid dilution rate tended to be higher for the higher protein diet. Passage rates were variable and were not related to digestion.

Introduction

When high grain diets are fed to cattle free choice, substantial quantities of readily fermentable substrates reach the large intestine. Although the cecum and proximal colon possess considerable fermentative capability (Orskov and Foot, 1968), large quantities of starch may escape digestion and appear in feces. Amounts depend on grain type and processing, level, type and form of roughage, and level of feed intake. With fermentation in the cecum and large intestine, fecal nitrogen loss may be elevated as microbial cells are passed in feces (Orskov et al., 1970). The extent of digestion or degradation of microbial protein in the hindgut is believed to be low. Amino acid absorption is presumably low or absent in this gut segment since amino acids, once free, are rapidly deaminated. Urinary nitrogen excretion may decrease to compensate when fecal loss of microbial N is elevated (Thornton et al., 1970). Pulling N to the cecum plus large intestine also could reduce recycling of N to the rumen and alter digestion by reducing ruminal ammonia-N concentrations. The objectives of this experiment were to determine the effects of ileal infusion of a physiological level of starch and of dietary nitrogen level on rate of passage and site of digestion by steers consuming a high concentrate diet.

Experimental Procedure

Three cannulated dairy steers (170 lb) were fed at 1.8 percent of body weight (dry matter basis) at 0800 and 2000 hr daily. Each of the four experimental periods lasted 7 days with ruminal, duodenal, ileal

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and fecal samples being obtained the final two days of each period. Steers received dosages in the ileum of either soluble potato starch (S; 12.0 to 13.1 g dry matter; .9 percent of dry matter intake) suspended in .85 percent NaCl (39.9 to 43.4 ml) or an equal volume of .85 percent NaCl (C) containing no starch at 0600 and 1800 hr daily. Delivery tubes were flushed with 20 ml of saline solution. Diets contained ground corn with 10 percent cottonseed hulls and 5 percent dehydrated alfalfa and 12.1 (L) or 15.1 percent (H) crude protein, with urea being added to increase the protein level. Diet type and intake level were designed to minimize postruminal starch passage to the ileum. Chromic oxide was included as an indigestible marker.

A particulate (ytterbium labeled ground corn) and a fluid marker (CoEDTA) were used to estimate ruminal passage rates. In addition, CoEDTA was dosed into the ileum to estimate hindgut fluid passage rate. Feed, ruminal, duodenal, ileal and fecal samples were subjected to all or part of the following analyses: pH, dry matter (DM), ash, N, acid detergent fiber (ADF), starch, chromium, nucleic acid-N, ammonia-N (NH_3-N), ytterbium and cobalt. The ratio of nucleic acid-N to microbial N was assumed to be .15 for duodenal, ileal and fecal samples.

Results and Discussion

Ruminal NH_3-N levels tended to be greater for steers fed the H than the L diet (Table 1). With the L diet, starch doses tended to decrease NH_3-N levels early after feeding while at later times, levels were slightly higher. These trends were reversed with the H diet. Ruminal ammonia concentration is a static measurement, and does not reflect ammonia kinetics. Ruminal, duodenal and fecal pH were similar for all treatments.

Passage rates (Table 1) were not correlated among liquids or particles or with other digestion measurements. The low intake level would not promote competition between passage rate out of and digestion rate in the rumen. Ruminal fluid passage rates were higher ($P<.05$) with the L than H diet. Fluid passage rate from the large intestine tended to be greater for the S than the C treatment. It appears that infused starch stimulated passage rate in the large intestine. This may be due to an osmotic effect or to enhanced microbial fermentation. Whether starch of dietary origin would elicit a similar response is unknown. Changes in cobalt concentration in feces following dose of CoEDTA into the ileum indicate that the hindgut may function as a mixing pool. By assuming 10 percent DM in ileal digesta, hindgut volumes of 35, 28, 20 and 24 ml/kg are derived for CL, CH, SL and SH treatments, respectively. These estimates are 24, 20, 19 and 14 percent of ruminal fluid volumes. Thus, starch infusion tended to decrease hindgut volume more with the L diet. This inverse relationship between volume and passage rate in the hindgut appears similar to occurrences often noted in the rumen.

Ruminal organic matter (OM) and starch digestion coefficients tended to be lower for animals receiving starch in the ileum (Table 1). Effects tended to be greater with the H than the L diet. Since ruminal ammonia levels were higher for the H than the L diet, ammonia levels do not appear to be responsible. Small intestinal starch disappearance was slightly greater for the S group, probably due to reduced starch disappearance in the rumen. An interaction ($P<.10$) was noted between starch infusion and protein level for hindgut starch digestion. This is partially explained by the quantities of starch leaving the ileum (Table 1). Possibly, starch doses with the L diet limited hindgut fermentation of dietary starch because of a N shortage in the hindgut. With the H

Table 1. Ruminal NH_3-N concentrations, digesta kinetics and digestion measures.

Item[ef]	Treatment				Infusion[d]		Diet[d]	
	CL	CH	SL	SH	C	S	L	H
Ruminal NH_3-N, mg/dl								
2 hr postfeeding	9.1	24.5	6.3	24.8	16.8	15.5	7.7^{a}	24.7^{b}
6 hr postfeeding	5.2	13.0	5.4	11.5	9.1	8.5	5.3^{a}	12.3^{b}
10 hr postfeeding	6.3	10.4	9.4	8.9	8.3	9.1	7.9	9.6
Ruminal fluid passage rate, hr^{-1}	.162	.077	.125	.087	.120	.106	.144	.082
Ruminal fluid volume, liter	11.2	10.9	8.1	12.7	11.0	10.4	9.6	11.8
Ruminal fluid flow rate, liters hr^{-1}	1.81	.84	1.01	1.10	1.32	1.10	1.38	.97
Hindgut passage rate, hr^{-1}	.112	.106	.152	.146	.109	.149	.132	.126
Particulate passage rate, hr^{-1}	.023	.037	.036	.034	.030	.035	.030	.036
Starch								
Ruminal digestion, %	69.7	74.3	64.8	66.9	72.0	65.8	67.2	70.6
Small intestinal digestion, %	9.9^{a}	16.9^{c}	21.5^{bc}	17.8^{ab}	13.4	19.4	15.5	17.3
Hindgut digestion, %	10.2^{a}	$.4^{c}$	3.6^{bc}	7.2^{ab}				
Total digestion, %	89.8	91.6	89.4	91.9	90.7	90.6	89.6	91.8
Exiting ileum, g/day	115	50	80	88	83	84	98	69
Exiting rectum, g/day	58	47	60	47	53	54	59	47
Digested in hindgut, g/day	57	3	20	41	30	30	39	22
Nitrogen								
Ruminal digestion, %	41.3	52.7	28.3	52.3	47.0	40.3	34.8	52.5
Small intestinal digestion, %	17.3	17.2	35.2	13.2	17.3	24.3	26.3^{a}	15.2^{b}
Total digestion (apparent), %	38.1	60.9	33.5	48.3	49.5	40.9	34.8^{a}	54.6^{b}
Total digestion (corrected for fecal MN), %	48.7	69.4	48.2	65.3	59.1	56.8	48.5^{a}	67.4^{b}
Total exiting rectum, g/day	16.8	13.1	17.9	17.4	14.9^{a}	17.7^{b}	17.3	15.3
Microbial exiting rectum, g/day	2.9	2.9	4.0	5.8	2.9^{a}	4.9^{b}	3.4	4.3
Fecal MN/total fecal N, %	17.3^{a}	22.1^{a}	22.3^{ab}	33.3^{b}	19.5^{a}	27.7^{b}	47.5	28.1
Ruminal ADF digestion, %	56.0^{a}	53.7^{a}	38.9^{ab}	14.0^{b}	54.8^{a}	26.5^{b}	47.5	33.9

[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.

[e] Infused starch was not considered in digestion measures.

[f] Digestion measures, % of intake.

diet, greater N cycling to the hindgut would permit fermentation of infused starch to continue and excretion of fecal N to increase. The difference between hindgut starch digestion between CH and SH treatments might also be due to a shift in bacterial types or metabolism in the hindgut for more extensive starch fermentation.

Ruminal N digestion tended to be greater for H than L animals (Table 1) as might be expected from absorption of the added NPN. Starch infusion did not alter ruminal N disappearance with the H diet, but tended to depress ruminal N disappearance with the L diet. The ruminal particulate passage rate for the SL steers was slightly greater than that of the CL treatment, possibly explaining a portion of the difference in extent of ruminal N digestion. Minimal NH_3-N levels necessary for maximal ruminal digestion of feed constituents have not been adequately established, but may be responsible for this difference. Small intestinal N disappearance tended to be greater for S than C and for L than H groups, probably due largely to differences in the ruminal output. Microbial efficiency varied inversely to ruminal starch digestion (14.4, 12.9, 20.4 and 24.0 gMN/kg OM fermented for CC, CH, SL and SH treatments, respectively). Ruminal digestion of ADF was lower for the S than the C treatment (Table 1). Ileal starch dosing decreased ruminal ADF disappearance more with the H than with the L diet. Results again suggest that unknown factors relate hindgut function to ruminal microbial activity.

Trends for increased fecal N excretion for H vs L and for S vs C groups were observed (Table 1). Fecal MN was increased by starch infusion. Fecal output of MN represented 11, 9, 15 and 17 percent of N intake for CL, CH, SL and SH treatments, respectively. Total tract N digestibility (NDIG) was greater for the H than for the L diet (Table 1). Starch infusion tended to depress NDIG more with the H than the L ration. However, correction of NDIG for MN contributions decreased the starch effect with the H diet and totally eliminated this effect with the L ration.

Results suggest that fermentation in the large intestine influences digestive function earlier in the tract. Explanation for observed responses are not all available. Further study is needed to more precisely explain the relationships between ruminal and hindgut fermentation.

Literature Cited

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