SITE AND EXTENT OF NITROGEN DIGESTION IN BEEF HEIFERS FED DIFFERENT COMBINATIONS OF DRY ROLLED CORN AND HIGH MOISTURE SORGHUM GRAIN

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Story in Brief

Dry rolled corn and high moisture harvested sorghum grain were fed in combinations of 100% dry rolled corn, 75:25, 50:50, 25:75 and 100% high moisture sorghum grain for the grain portion to determine their effect on site and extent of nitrogen digestion and microbial efficiency. Diets were fed at 2% of body weight (dry basis) in a 5 X 5 Latin square using Hereford-Angus heifers (693 pounds) equipped with ruminal, duodenal and ileal T-type cannulae. Total tract nitrogen digestibility decreased linearly with the addition of high moisture sorghum grain. Feed nitrogen digestion in the rumen and ruminal escape of feed nitrogen tended to increase quadratically when greater levels of high moisture sorghum grain were added to the diet. Microbial efficiency was low for all diets (12.9 grams microbial crude protein/kilogram of organic matter fermented). However, a linear increase in microbial efficiency occurred as more high moisture sorghum grain was included. The small intestine tended to compensate for decreased nitrogen digestion in the rumen and resulted in no apparent influence of grain combinations on nitrogen digestion through the ileum (average 71.3%).

(Key Words: Sorghum, Corn, Nitrogen Digestion.)

Introduction

High moisture harvesting of grain is not a new idea; however, increasing sorghum production, the rising cost of traditional grain processing and declining production of irrigated corn have renewed interest in high moisture harvesting of sorghum grain. Combining high moisture sorghum and dry rolled corn grains should reduce the management demands of high moisture grain feeding. In practice, price rather than digestibility or performance often dictates the combination of grains and processing methods. Little work has been conducted to determine the effect of different combinations of dry and high moisture grains on site and extent of nitrogen digestion and microbial efficiency. The correct combination of high moisture sorghum grain and dry rolled corn may maximize nitrogen digestion and microbial efficiency in the rumen. The objective of this study was to determine the influence of different combinations of dry rolled corn and high moisture harvested sorghum grain on site and extent of nitrogen digestion and efficiency of microbial protein production.

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Materials and Methods

Five diets (Table 1) were created with dry rolled corn (DRC) and ground high moisture harvested sorghum grain (HMS). Combinations of DRC:HMS consisted of 100:0, 75:25, 50:50, 25:75, and 0:100 on a dry matter basis for the grain component of the diet. Initial analysis of grain samples indicated that urea could not be incorporated as the only source of supplemental nitrogen (N); therefore, soybean meal was added at equal levels (5.2% DM) to all diets, and urea was added to balance diets for crude protein.

Diets were fed twice daily at 2% of initial body weight (DM basis) to five Hereford-Angus heifers (693 lb) fitted with ruminal, duodenal and ileal T-type cannulae. A 5 X 5 Latin square was used with 10 day periods. Days 1 through 7 were for diet adaptation and days 8 through 10 for digesta and fecal collection. Ruminal fluid was collected on day 10 of each period, acidified and stored at -4 F prior to ammonia analysis. Additional rumen fluid was collected during periods 3 and 5 for bacterial N analysis. Feed samples were ground through a 1mm screen in a laboratory Wiley mill, with dry ice to facilitate grinding, and stored at -4 F prior to analysis. Digesta and fecal samples were freeze dried prior to grinding through a 1mm screen in a laboratory Wiley mill, storage at -4 F and analysis. Samples were analyzed for all or part of the following: dry matter, ash, starch, crude protein, ammonia N (NH_3), RNA-N (total purines), sodium chloride soluble N (NaCl-N), pepsin insoluble N (PIN) and chromic oxide. Nitrogen digestibility and escape were determined by RNA-N and chromic oxide ratios. Orthogonal polynomials were used to evaluate the relationship between least squares means of diet effects.

Results and Discussion

Starch ($P<.10$) and crude protein ($P<.05$) content of the complete mixed feeds responded quadratically with less DRC (Table 2). NaCl-N ($P<.05$) and PIN ($P<.01$) content of the diets increased cubically with the addition of HMS. High moisture harvesting of grain generally increases soluble N and decreases indigestible N. Increased N

Table 1. Ingredient composition of experimental diets (DM basis).

	DRC:HMS				
Ingredient (%DM)	100:0	75:25	50:50	25:75	0:100
Dry rolled corn	83.2	62.6	41.8	20.9	0.0
High moisture sorghum	0.0	20.8	41.8	62.7	83.8
Cottonseed hulls	8.0	8.0	8.0	8.0	8.0
Soybean meal	5.2	5.2	5.2	5.2	5.2
Urea	1.0	.87	.76	.65	.53
Supplement					
Sodium sulfate	.17	.15	.13	.11	.09
Dicalcium phosphate	.44	.44	.44	.44	.44
Calcium carbonate	.93	.93	.93	.93	.93
Potassium chloride	.57	.57	.57	.57	.57
Chromic oxide	.20	.20	.20	.20	.20
Vitamin A (IU/Kg)	2200				

Table 2. Chemical characteristics of grains and feeds.

Item (%)	DRC:HMS 100:0	75:25	50:50	25:75	0:100
Grain					
Starch	78.5				84.0
Crude protein	9.5				9.8
NaCl soluble N[a]	13.9	23.3	36.8	50.7	61.8
Pepsin insoluble N[b]	14.2	13.2	10.5	8.7	6.7
Feed					
Starch	66.5	65.7	65.8	66.5	71.0
Crude protein[c]	12.8	14.0	13.8	13.4	12.9
NaCl soluble N[a]	37.6	39.9	43.7	52.8	51.4
Pepsin insoluble N[d]	12.3	11.1	9.2	10.2	8.8

[a] Cubic ($P<.05$).
[b] Linear ($P<.01$).
[c] Quadratic ($P<.05$).
[d] Cubic ($P<.01$).

solubility should increase starch digestibility due to increased accessibility of starch granules.

Non-ammonia-N (NAN) digestibility in the total tract (Table 3) decreased linearly ($P<.05$) with increased HMS. Total tract NAN digestibility remained relatively constant through 50% HMS (72.4%) and fell when greater amounts of HMS were included in the diet (67.6%). Low levels of HMS (<50%) may not depress N digestion; however, quadratic effects were far from significant ($P>.20$). N digestibility may have been depressed by HMS because of lower degradability of sorghum protein compared to corn protein. However, HMS had greater NaCl-N and lower PIN than DRC in this study.

Ruminal pH increased linearly ($P<.05$) with more HMS. Previous research would suggest that ruminal pH should decrease with the inclusion of high moisture grain. Perhaps the acid load presented to the rumen with high moisture sorghum may have stimulated salivary flow thereby increasing ruminal pH. Duodenal chyme flow supports this concept with a linear increase ($P<.01$) as HMS levels in the diet increased. Ruminal ammonia-N concentration tended to increase linearly ($P<.10$) as higher levels of HMS were fed. Declining ruminal organic matter digestion, reported previously, may be responsible for the simultaneous increase in ruminal ammonia concentration. Total feed N disappearance from the rumen tended to increase quadratically ($P<.10$), at a decreasing rate, with higher levels of HMS. Total feed N disappearance in the rumen appeared to increase through 75% HMS (55.5%) and decrease dramatically at 100% HMS (44.1%). Ruminal N disappearance resulted in a quadratic decrease in escape of N from ruminal degradation ($P<.10$). Salivary flow and increasing pH with HMS may have affected the solubility and degradability of DRC and HMS proteins differently resulting in quadratic bypass and digestion of feed N. Different combinations of DRC and HMS may also have altered the microbes ability to degrade protein.

The efficiency of microbial protein synthesis increased linearly ($P<.05$) as HMS replaced DRC in the diet. Increased microbial efficiency is the result of increased ($P<.05$) microbial N flow to the duodenum and

Table 3. Influence of different combinations of DRC and HMS on nitrogen digestion.

Item	DRC:HMS 100:0	75:25	50:50	25:75	0:100
Intake (g/d)					
Total N	128.1	139.1	134.6	135.8	130.3
Non-urea feed N	99.1	113.9	112.6	116.4	114.7
Total tract N digestibility based on:					
Fecal non-ammonia nitrogen (NAN)[a]	72.5	72.8	72.4	67.6	65.9
Rumen environment					
pH[b]	5.84	6.03	6.05	6.06	6.14
NH_3-N (mg/dl)	5.36	8.30	6.80	8.43	8.15
Duodenal N appearance					
g/d	117.7	125.4	121.3	123.4	134.6
Ruminal N disappearance					
Feed-N (g/d)	65.2	68.0	62.7	60.4	70.9
Total feed N (%)	49.1	51.1	53.4	55.5	44.1
Feed N escape (%)	65.8	59.7	55.7	51.9	63.5
Microbial efficiency					
g MP / kg OMF	11.5	12.5	12.6	13.9	13.8
NAN disappearance in the small intestine					
g/d	79.5	80.1	78.2	74.6	88.4
% of entry	68.0	67.1	67.0	64.2	69.4
% of intake	62.2	58.0	58.1	54.9	67.8
NAN disappearance through the ileum					
% of intake	71.3	72.7	72.6	69.4	70.3
% of total tract	99.6	100.2	100.4	102.9	107.3

[a] Linear ($P<.01$).
[b] Linear ($P<.05$).

decreased ($P<.10$) ruminal organic matter (corrected) disappearance. Increased chyme flow (linear, $P<.01$) could indicate increased liquid dilution rate and may be responsible for the observed linear increase in microbial efficiency.

Nitrogen digestibility through the ileum (Table 3) as a percent of N intake did not appear to be altered by the level of HMS in the diet. NAN digestion through the ileum (% of total tract) accounted for all N disappearance in the total tract (102.1%). The small intestine tended ($P<.15$)to compensate (% of N intake) for quadratic N digestion in the rumen. However, digestion, as a percent of NAN entering the small intestine, did not respond significantly to different combinations of grain and averaged 67.1%.

Microbial fermentation in the rumen appeared to be more responsive to different combinations of DRC and HMS than enzymatic digestion in the small intestine. However, possible benefits of increased feed N bypass of ruminal degradation are totally dependent on the amino acid composition of digesta reaching the small intestine and amino acid requirements of cattle. If microbial efficiency and microbial N production are maintained at high levels then increased escape of low quality corn protein to the small intestine may be less advantageous than improving protein quality through ruminal fermentation.