COMPARISON OF SITE AND EXTENT OF NITROGEN DIGESTION OF CORN AND FOUR SORGHUM GRAIN HYBRIDS IN BEEF STEERS

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Story in Brief

To compare the effect of corn and sorghum grain hybrids on site and extent of nitrogen digestion, four currently available sorghum grain hybrids (pure yellow, cream, hetero-yellow and red) and a commercially obtained corn were dry rolled and fed in an 85% grain diet to Angus x Hereford steers (531 lb) equipped with large ruminal and double L duodenal and ileal cannulae. Diets were fed at 2% of body weight (dry matter basis) in a 5x5 latin square. Ruminal escape of feed nitrogen was greater for red than other grains, with corn having less ruminal escape of feed nitrogen than the sorghum grain hybrids. Pre-cecal non-ammonia nitrogen digestibility was not altered by grain type; however, non-ammonia nitrogen flow to the cecum was greater for red than other grains. Disappearance and digestibility in the small intestine tended not to be affected by grain type; although, nitrogen in corn appeared to be slightly more digestible than nitrogen in sorghum hybrids, particularly yellow and red. Nitrogen from corn and the sorghum grain hybrids was not digested equally at all sites. Lower ruminal feed nitrogen digestion for sorghum grains compared to corn may decrease the supply of essential amino acids to the small intestine for steers fed sorghum if less microbial protein is synthesized.

(Key Words: Sorghum Grain, Corn, Nitrogen, Digestion, Beef Steers.)

Introduction

Cereal grains represent the major sources of energy and protein in feedlot diets. Nationally, corn is the most prominent grain fed, but sorghum grain is extensively used in some regions. Sorghum grain generally is regarded as being more variable in quality and less digestible than corn. However, improvement in sorghum grain hybrid strains may make sorghum

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more competitive with corn. Currently, available sorghum hybrids have not been compared to corn to determine the potential improvement in nutritional quality of sorghum relative to corn. Therefore, the objective of this study was to assess differences in site and extent of nitrogen (N) digestion of corn and four currently available sorghum grain hybrids.

Materials and Methods

Four sorghum grain hybrids (Table 1), representing a pure yellow (homozygous yellow endosperm, yellow seed coat, denoted as Yel), cream (heterozygous yellow endosperm, white seed coat), hetero-yellow (heterozygous yellow endosperm, red seed coat, denoted as Het-Yel) and red (homozygous white endosperm, red seed coat), were grown under dryland conditions in southeast Kansas during the summer of 1986. Rainfall was evenly distributed throughout the growing season and totaled 15 inches. Corn was obtained commercially. All grains were dry rolled before feeding in an 85% grain diet (Table 2). Molasses was included in the diet (3% of DM) to reduce dust. Urea was used as the sole source of supplemental N to enhance the estimation of feed N digestion in the rumen. Chromic oxide (.2% DM) was used as a digestibility marker.

Diets were fed three times daily to 531 lb Angus x Hereford steers surgically equipped, while under local anesthesia, with permanent ruminal and double L duodenal and ileal cannulae. Daily dry matter intake was restricted to 2% (DM basis) of steer weight to ensure uniform consumption within a 5x5 latin square. Experimental periods lasted 14 days with days 1 through 11 for diet adaptation and 12 through 14 for feed, digesta and fecal sampling. Samples were collected at 1200, 1600 and 2400 on day 12, 0600, 1500 and 2100 on day 13 and 0300 and 0900 on day 14. Ruminal fluid was collected at 1500 and 2100 on day 13 and 0300 and 0900 on day 14. Ruminal fluid was acidified after pH determination. Digesta and fecal samples were composited across day and time within each period, lyophilized and ground through a 1 mm screen. Ruminal fluid was also collected at 1400 h during

Table 1. Descriptive characteristics of sorghum grain hybrids.

Sorghum hybrid	Seed coat color	Endosperm color	Endosperm cross
Yellow	yellow	yellow	yellow x yellow
Cream	white	yellow	white x yellow
Hetero-yellow	red	yellow	white x yellow
Red	red	white	white x white

Table 2. Ingredient composition of experimental diets.

Ingredient[a]	% of dry matter
Grain	85.0
Cottonseed hulls	8.0
Molasses	3.0
Supplement	
Urea	1.20
Dicalcium phosphate	.44
Calcium carbonate	.93
Potassium chloride	.57
Sodium sulfate	.36
Trace mineralized salt	.25
Chromic oxide	.20

[a]Vitamin A was included at a level of 2200 IU/kg.

periods 2, 3, 4 and 5 for determination of microbial nitrogen flow to the small intestine.

Grain, feed, duodenal, ileal, fecal and microbial samples were analyzed for dry matter, ash, crude protein, ammonia-N, purine-N (RNA basis) and chromic oxide. Grain samples also were analyzed for sodium chloride soluble protein (NaCl-N) and pepsin insoluble N (PIN). Nitrogen digestibility was determined by chromic oxide ratio, while purine-N was utilized to distinguish feed protein from microbial protein escaping the rumen. Volume of sorghum grain berries was determined by measuring the volume of toluene that was displaced by 100 berries randomly selected from each hybrid. Least squares means were separated by a protected least significant difference.

Results and Discussion

The red sorghum grain hybrid contained more ($P<.05$) crude protein (CP) than cream, Het-Yel and Yel, while corn contained an intermediate amount of CP (Table 3). Corn and Yel contained more NaCl-N than red, while cream was intermediate, with all other grains being greater ($P<.10$) than Het-Yel. PIN was similar for all grains, averaging 12.2% of CP N. Among sorghum hybrids, Het-Yel had larger ($P<.05$) berries (g/100 berries) than other sorghum grain types, while Yel and red had larger ($P<.05$) berries than cream. The volume of individual berries was greater ($P<.10$) for Het-Yel than Yel and cream with Yel greater than cream. Red berries were intermediate in volume to Het-Yel and Yel. If all hybrids contained the same proportion of corneous and floury endosperm, larger berries should

Table 3. Chemical composition of corn and sorghum grain hybrids and complete mixed feeds (DM basis).

Item	Corn	Yellow	Cream	Hetero-yellow	Red
Grain					
CP	10.0^{ab}	9.5^{b}	9.7^{b}	9.6^{b}	10.4^{a}
Starch	72.2	78.7	78.3	72.9	79.6
ADF	7.7	7.3	9.6	9.0	8.5
NaCl soluble protein, % of total N	30.9^{X}	30.8^{X}	27.6^{XY}	21.4^{Z}	26.5^{Y}
Pepsin insoluble nitrogen, % of total N	12.4	11.1	12.5	12.2	12.8
Berry size, g/100 berries	--	2.22^{b}	1.98^{c}	2.53^{a}	2.27^{b}
Berry volume, µl/berry	--	18.0^{Y}	15.5^{Z}	20.5^{X}	19.0^{XY}
Density, g/ml	--	1.24	1.28	1.24	1.20
Feed					
CP	12.1^{c}	12.6^{b}	12.5^{b}	12.6^{b}	13.5^{a}
Starch	64.7	65.1	62.6	66.4	65.2
ADF	5.4	5.6	6.5	5.7	5.6
Grain particle size					
Geometric mean, µm	3316^{a}	785^{bc}	684^{c}	903^{b}	695^{c}
>4000 µm, %	76.0^{a}	$.2^{b}$	$.2^{b}$	$.2^{b}$	$.2^{b}$
3999-2000 µm, %	22.0^{W}	3.4^{YZ}	1.8^{X}	7.1^{X}	4.6^{Y}
1999-1000 µm, %	1.4^{Z}	75.8^{X}	65.2^{Y}	79.8^{X}	64.0^{X}
999-500 µm, %	$.2^{c}$	9.3^{b}	13.0^{a}	7.3^{b}	15.2^{a}
499-250 µm, %	.1	4.3	7.8	1.8	5.6
<250 µm, %	$.2^{Z}$	7.0^{XY}	11.9^{X}	3.8^{YZ}	10.6^{X}

^{a,b,c}Means in the same row with different superscripts differ (P<.05).
^{w,x,y,z}Means in the same row with different superscripts differ (P<.10).

result in a smaller average geometric mean diameter of particles when rolled. However, the berries of greatest size and volume, Het-Yel, resulted in a larger (P<.05) geometric mean diameter of particles than did cream and red, with Yel being intermediate to Het-Yel and red. This may suggest that Het-Yel and Yel contain a larger proportion of the endosperm as less digestible corneous endosperm than do cream and red.

Steers fed the red sorghum hybrid consumed more N than when fed Het-Yel, Yel and cream, with corn being lower than all sorghum hybrids (Table 4). With all diets, a net gain in the amount of N reaching the duodenum above actual N intake levels was observed. A gain in N through the rumen indicates nitrogen recycling to the rumen. Ruminal feed N (excluding urea) digestibility was greater for corn (P<.10) than for sorghum grain hybrids, with pure yellow (Yel) and partial yellow endosperm hybrids (cream and Het-Yel) being more (P<.10) digestible than the white endosperm red sorghum. Pre-cecal non-ammonia N (NAN) digestibility was

Table 4. Comparison of site and extent of nitrogen digestion of corn and four sorghum grain hybrids.

Item	Corn	Yellow	Cream	Hetero-yellow	Red
Ruminal NH_3 N, mg/dl	7.60	10.02	7.81	9.45	8.36
Nitrogen intake, g/d					
Total feed N	93.8	97.7	97.3	98.0	103.9
Feed N(excluding urea N)	67.1	71.1	70.5	71.3	77.3
Duodenal non-NH_3 N, g/d	101	100	101	102	115
Microbial N	66.1	53.7	54.4	52.9	52.8
Feed N	35.1^{c}	46.7^{b}	46.8^{b}	49.3^{b}	61.9^{a}
Pre-cecal non-NH_3 N, g/d	34.8^{b}	39.9^{b}	36.2^{b}	36.9^{b}	46.0^{a}
Fecal on-NH_3 N, g/d	36.0^{z}	41.0^{yz}	39.7^{yz}	41.5^{y}	46.7^{x}
Nitrogen digestibility, % of intake					
Feed N(excluding urea N)	46.4^{x}	33.9^{y}	33.5^{y}	30.8^{y}	20.1^{z}
Ruminal escape feed N, %	53.6^{z}	66.1^{y}	66.5^{y}	69.2^{y}	79.9^{x}
Pre-cecal non-NH_3 N	62.4	59.3	62.6	62.2	55.8
Total tract non-NH_3 N	61.0	58.1	59.1	57.6	55.1
Non-ammonia N digestibility in the small intestine					
disappearance, g/d	66.4	60.5	65.0	65.2	68.7
% of entry	65.4	59.8	63.5	63.7	59.5
% of intake	71.8	62.1	66.4	66.5	65.9

^{a,b,c}Means in the same row with different superscripts differ ($P<.05$).
^{x,y,z}Means in the same row with different superscripts differ ($P<.10$).

similar for all grains, averaging 60.5%; however, NAN flowing out of the ileum was greater ($P<.05$) for red than other grains.

Digestibility of NAN in the small intestine, as proportion of intake, also was similar for all grains, averaging 66.5% of N intake. When digestibility was expressed as a percentage of NAN flow to the small intestine, corn appeared ($P>.10$) to be slightly more digestible than sorghum hybrids, particularly Yel and red.

Total tract NAN digestibility was only slightly greater ($P>.10$) for corn than for sorghum grain hybrids. Among sorghum hybrids the Yel and partial yellow endosperm (cream and het-yel) hybrids appeared to be slightly more digestible than the white endosperm (red) hybrid.

Corn protein may be more digestible or degradable in the rumen than sorghum protein because of differences in protein solubility and because

larger corn particles are possibly retained in the rumen longer than smaller sorghum particles. However, due to greater surface area, the smaller sorghum particles may need a shorter retention period to be digested. Lower ruminal digestibility for sorghum protein could also result from a greater proportion of peripheral endosperm, containing more poorly extractable protein, compared to corn. Likewise, differences observed among sorghum hybrids may be the result of variation in peripheral endosperm, but also cross linking of prolamine protein fractions within the peripheral endosperm.

The site and extent of nitrogen digestibility was affected by corn and sorghum grain hybrid. Differences in ruminal digestibility may influence the quality of protein available for digestion and absorption in the small intestine. Although, specific amino acid requirements are not defined for beef cattle, differences in the quality of protein (feed versus microbial) digested in the small intestine could impact performance of feedlot cattle.