EFFECT OF ALTERING THE RATIO OF DRY ROLLED CORN TO HIGH MOISTURE HARVESTED SORGHUM GRAIN ON SITE AND EXTENT OF STARCH DIGESTION IN HEIFERS

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Story in Brief

Dry rolled corn and high moisture harvested sorghum grain were fed in diets of 100% dry rolled corn, 75:25, 50:50, 25:75 and 100% high moisture sorghum grain to determine their effect on site and extent of starch digestion. Diets were fed at 2% of body weight (dry basis) in a 5x5 Latin square using Hereford-Angus heifers (693 lb) equipped with ruminal, duodenal and ileal T-type cannulae. Total tract starch digestibility decreased linearly with more high moisture sorhgum grain. Starch disappearance (g/day) from the rumen decreased quadratically with more high moisture sorghum grain (average of 82.7% across all blends). No difference was noted at the ileum (86.2%). Starch digestion in the small intestine was low for all diets, averaging only 21.4% of starch entry and 3.8% of starch intake. As in the rumen, fermentation of starch in the large intestine decreased linearly with more high moisture sorghum grain. Quantitatively, the large intestine was a more important site of disappearance than the small intestine (4.8% vs 3.8% of starch intake). The greatest benefit of blending may be reduced processing, decreasing ration cost.

(Key Words: Sorghum Grain, Corn Blends, Starch Digestibility)

Introduction

High moisture sorghum grain (HMS) deserves consideration as an energy source in feedlot diets because of increasing sorghum production, the rising cost of grain processing and declining production of irrigated corn. Blending of high moisture and dry grains does occur, but price rather than digestibility or cattle performance usually dictates the ratio between grain types. Little work has been conducted to determine the effect of blending dry and high moisture grains on site and extent of starch digestion, although speculation has been great based on indicated improvements in animal performance. A combination of fermentable high moisture sorghum and dry coarsely rolled corn (DRC) may maximize starch fermentation in the rumen, digestion in the small intestine and digestion in the total tract while minimizing fermentation in the large intestine. No work exists using blends of dry coarsely rolled corn and high moisture harvested sorghum. The objective of this study, therefore, was to determine the effects of altering the ratio of dry coarsely rolled corn to high moisture harvested sorghum grain on site and extent of starch digestion.

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Materials and Methods

Five diets (Table 1) were created using ground high moisture harvested sorghum grain (HMS) and dry rolled corn (DRC). Blends of DRC:HMS were 100% DRC, 75:25, 50:50, 25:75 and 100% HMS (DM basis), denoted as 0, 25, 50, 75 and 100, respectively. Initial analyses indicated urea could not be used as the only nitrogen supplement. Therefore, soybean meal was added at equal levels to all diets, and urea used to balance for crude protein.

Blends were fed twice daily at 2% of body weight (DM basis) to five Hereford-Angus heifers (693 lbs), fitted with ruminal, duodenal, and ideal T-type cannulae. A 5x5 Latin square was used with periods lasting 10 days. Days 1 through 7 were for adaptation and days 8 through 10 were for digesta and fecal sample collection. Feed samples were ground through a 1 mm screen in a Udy mill, using dry ice to facilitate grinding, and stored at -20 C prior to analyses. Digesta and fecal samples were dried using a lyophilizer prior to grinding through a 1 mm screen in a Udy mill. Samples were analyzed for all or part of the following: dry matter, starch (glucose polymers), crude protein, sodium chloride soluble nitrogen, pepsin insoluble nitrogen and chromium. Starch digestibility was determined by chromic oxide ratios. Orthogonal polynonials were used to determine the relationship between least squares means of blends.

Results and Discussion

Starch ($P < .10$), crude protein ($P < .05$) and pepsin insoluble nitrogen ($P < .01$) content of the complete mixed feeds responded quadratically with less DRC (Table 2). Sodium chloride soluble nitrogen

Table 1. Ration composition of experimental diets.

	DRC:HMS				
Ingredient (%DM)	0	25	50	75	100
Dry rolled corn	83.2	62.6	41.8	20.9	0.0
High moisture sorghum	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					
Dicalcium phosphate	.44	.44	.44	.44	.44
Calcium carbonate	.93	.93	.93	.93	.93
Potassium chloride	.57	.57	.57	.57	.57
Sodium sulfate	.17	.14	.13	.11	.09
Trace mineral salt	.25	.25	.25	.25	.25
Chronic oxide	.20	.20	.20	.20	.20
Vitamin A (IU/kg)	2200				

Table 2. Chemical characteristics of grains and feeds.

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

[a]Cubic (P<.05).
[b]Linear (P<.01).
[c]Quadratic (P<.10).
[d]Quadratic (P<.05).
[e]Quatric (P<.01).

content of the complete mixed feeds increased (P<.05) cubically with more HMS. High moisture harvesting of grains generally causes an increase in sodium chloride soluble nitrogen and a decrease in pepsin insoluble nitrogen (PIN) level.

Total tract starch digestiblity (Table 3) tended to decrease (P<.10) linearly with more HMS. Although a statistical linear decline was observed, total tract starch digestiblity appeared to remain relatively constant through blend 50 (92.4, 92.4, 93.0, 89.5 and 88.2 on 0, 25, 50, 75 and 100%, respectively) and decline with higher levels of HMS. Reports for blends of high moisture and dry rolled corn have generally suggested improved performance with more high moisture corn. However, comparisons between DRC:HMS blends and corn blends are probably not valid due to physical and chemical differences between corn and sorghum grains.

Starch digestion (% of entry) in the rumen did not appear to be influenced by the level of HMS. An increase in starch digestion in the rumen may have been anticipated with a high moisture grain based on information obtained with other processing methods. However, differences in the type of grain (corn vs sorghum) were probably an important factor. Since starch intake increased somewhat with more HMS, ruminal starch disappearance values on a percentage basis are perhaps hard to interpret; therefore, the actual amount of starch disappearing (g/d) from the rumen may be a better indicator of digestion. Starch disappearance (g/d) from the rumen increased (P <.05) quadratically with the inclusion of HMS in the blend, suggesting the occurrence of some associative effects between DRC and HMS. Associative effects may be caused by changes in the solubility of DRC and HMS proteins, altering starch availability.

Table 3. Site and extent of starch digestion of DRC:HMS blends.

Item	0	25	50	75	100
Starch intake (g/day)	4136	4079	4138	4204	4495
Starch disappearance (Rumen)					
g/day[a]	3542	3371	3476	3316	3709
% of intake	85.6	82.6	84.0	78.9	82.5
Starch disappearance (Ileum)					
% of intake	85.6	88.0	87.5	83.9	86.1
% of total tract	93.4	95.3	94.1	93.6	97.6
Starch disappearance (SI)					
g/day	71.2	220.3	140.1	209.3	161.5
% of entry	13.4	32.6	13.8	24.6	22.6
% of intake	1.7	5.4	3.4	5.0	3.6
Starch disappearance (LI)					
g/day	250.6	178.5	227.4	238.4	93.8
% of entry[b]	53.8	38.4	43.0	22.8	9.4
% of intake	6.1	4.4	5.5	5.7	2.1
Starch disappearance (Total tract)					
g/day	3823.7	3769.4	3847.8	3764.4	3964.5
% of intake	92.4	92.4	93.0	89.5	88.2

[a]Quadratic ($P<.05$).
[b]Linear ($P<.05$).
[c]Linear ($P<.10$).

Starch disappearance through the ileum (% of intake) did not differ statistically with increasing HMS, averaging 86.2%. Starch digestion (% of total tract disappearance) was nearly complete (94.8%) at the ileum.

Starch digestion in the small intestine, like digestion through the ileum, did not respond statistically to increasing levels of HMS. Starch digestion, therein, averaged a low of 21.4% of starch entering the small intestine. Quantitatively, the rumen (82.7% of starch intake) was a much more important site of digestion than the small intestine (3.8% of starch intake). Starch digestion in the small intestine may have been limited by extensive digestion in the rumen, resulting in only that starch deeply imbedded in protein matrix being presented to the small intestine for digestion.

Fermentation of starch in the large intestine (% of entry) declined ($P<.05$) linearly, with more HMS, from 53.8% (100% DRC) to 9.4% (100% HMS), representing from 6.1% to 2.1% of total starch consumption. Decreased starch fermentation in the large intestine may have been caused by more protein matrix and lower protein solubility in the sorghum grain. Quantitatively, the large intestine was a more important site of starch digestion (average of 4.8% of total starch intake) than the small intestine (3.8%). From an energetic standpoint, starch digested in the small intestine would be more efficient to the animal, while starch fermentation in the large intestine may result in an energy loss in the form of undigested microbial organic matter.

Microbial fermentation in the rumen and large intestine appeared to be more responsive to the ratio of DRC to HMS than digestion in the small intestine. These results suggest that HMS can be included in a blend; however, starch digestion appeared to decline especially when HMS represented 75% or more of the grain. One of the greatest benefits of blending may be economic. If processing costs can be reduced for a portion of the ration, while performance is improved or maintained, the cost of gain should be reduced. Further studies with other blends may be beneficial in improving digestibility and performance, while decreasing ration costs.