FERMENTED CORN GRAIN-SITE AND EXTENT OF NUTRIENT DIGESTION IN STEERS

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Story in Brief

Ground high moisture corn was reconstituted with addition of water to levels of 15, 20, 25, 30 and 35 percent moisture and allowed to ferment for 30 days. These products were fed as 80 percent of the diet dry matter to five cannulated steers. As moisture level increased, dry matter and organic matter digestibilities in the rumen and total tract decreased and then increased. Starch digestibility in the rumen and in the total digestive tract increased linearly with water addition while fiber digestibility in the rumen tended to decrease. Highest ruminal and total tract digestibilities of organic matter and starch were with the wettest grain. Microbial protein passage to the duodenum increased with moisture addition.

Introduction

Fermentation of cereal grains prior to feeding can increase feeding value as measured by efficiency of feed use. This may be due to an increase in nutrient digestibility with fermentation. Total digestibility of organic matter and starch is typically greater for high moisture corn (HMC) than when dry corn is fed whole, rolled or ground. However, feed efficiency and digestibility may differ with moisture content of HMC. The extent of ruminal digestion appears to be greater with high moisture than with dry corn; although, the influence of various moisture levels on extent of ruminal and small intestinal digestion has not been studied directly. This study was conducted to determine the effect of moisture level of reconstituted HMC on site and extent of digestion by steers.

Materials and Methods

A 5 x 5 Latin square design experiment was employed with five steers (1170 lb), moisture levels and periods. Ground corn was reconstituted to 15, 20, 25, 30 and 35 percent moisture, packed in plastic bags which were evacuated with a vacuum pump, and held at 102 F for a minimum of 60 days prior to feeding. Reconstituted grain rather than high moisture harvested grain was used in this study to remove seasonal effects and varietal differences which often are confounded with harvest at different moisture levels. The diet was comprised of approximately 80 percent corn, 14 percent cottonseed hulls and 6 percent supplement. Chromic oxide was included as an indigestible marker. Steers were fed twice daily at 0800 and 2000 hr. The steers were fitted with ruminal, duodenal and ileal cannulae. In each 10-day period, the first seven were used for adaptation to the new moisture level and the final three days were used for sample collection.

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Results and Discussion

Dry matter (DM) and organic matter (OM) digestibility coefficients for the different segments of the digestive tract tended to be highest at the two extreme moisture levels (Table 1). The highest ruminal DM digestibility was with the lowest level of water. This may be attributed to higher ruminal acid detergent fiber (ADF) digestibility with the 15 percent group (Table 2). Higher ruminal pH with the 15 percent treatment, supporting a higher population of cellulolytic bacteria, may have been responsible. Lower ruminal pH with HMC vs dry corn has been noted previously.

Ruminal OM digestion, corrected for microbial OM flow, was greatest for the 35 percent treatment. Microbial efficiency was greater for the 25 percent group than for 15 and 20 percent treatments ($P<.05$), while the 30 and 35 percent levels were intermediate (Table 1).

Table 1. Effect of fermentation on DM digestion and OM digestion and passage.

Item	Water percent				
	15	20	25	30	35
DM digestion, %					
Rumen	60.3^{a}	56.6^{ab}	50.9^{c}	55.4^{b}	59.7^{ab}
Small intestine	31.7	37.3	45.7	35.2	37.7
Large intestine	19.0_{ab}	17.8_{ab}	17.8_{ab}	78.4_{b}	26.8_{a}
Total	78.3^{ab}	77.0^{ab}	78.4^{ab}	76.0^{b}	82.1^{a}
OM passage, lb					
Intake	19.4	20.9	19.5	19.3	18.5
Total OM entering duodenum	6.6^{bc}	7.9^{ab}	8.2^{a}	7.4^{abc}	6.2^{c}
Microbial OM entering duodenum	2.3^{b}	2.5^{b}	3.1^{a}	2.8^{ab}	2.8^{ab}
Exiting ileum	4.7_{ab}	5.1_{ab}	4.8_{ab}	4.8_{ab}	4.0_{b}
Exiting rectum	3.9^{ab}	4.3^{a}	3.9^{ab}	4.3^{a}	3.0^{b}
OM digestion, %					
Rumen, apparent	65.5^{a}	62.6^{ab}	58.0^{c}	61.3^{bc}	66.5^{a}
Rumen, true	77.4^{b}	74.7^{b}	74.0^{b}	75.8^{b}	81.9^{a}
Small intestine	29.6	33.0	42.5	34.4	33.4
Large intestine	15.6_{ab}	16.9_{ab}	16.8_{ab}	12.2_{b}	24.2_{a}
Total	79.7^{ab}	79.5^{ab}	80.0^{ab}	78.1^{b}	83.6^{a}
Microbial efficiency, g of microbial N/kg of OM fermented	11.0^{c}	11.8^{c}	15.5^{a}	13.7^{b}	13.5^{b}

^{abc}Means in a row with different superscripts differ ($P<.05$).

The greatest large intestinal DM digestibility was observed with 35 percent moisture (Table 1), possibly due to renewed digestion of fiber. Since the smallest quantity of starch reaching the large intestine was with this diet, starch digestion would be minimal that could facilitate extensive fiber fermentation. Total DM digestibility was fairly constant with increasing moisture level until the 35 percent level. As water level increased, both ruminal and total starch digestibilities

Table 2. Effect of fermentation on starch and ADF digestion.

Item	Water percent 15	20	25	30	35
Starch digestion, %					
Rumen	86.7[b]	87.7[ab]	89.1[ab]	93.0[ab]	95.7[a]
Small intestine	65.5[ab]	59.0[b]	71.7[ab]	68.7[ab]	88.8[a]
Large intestine	47.2	46.8	44.9	65.5	53.4
Total tract	96.7[b]	97.8[b]	98.7[ab]	99.6[a]	99.7[a]
ADF digestion, %					
Rumen	59.1[a]	52.8[ab]	34.3[b]	37.5[b]	55.3[ab]
Small intestine	-37.6	-24.1	.5	-33.3	-68.6
Large intestine	2.9	2.4	2.1	0.0	15.4
Total tract	49.0[a]	48.2[a]	38.2[a]	24.7[b]	42.6[a]

[ab]Means in a row with different superscripts differ (P<.05).

increased linearly (Table 2). The treatment pattern of small intestinal starch digestion was similar to ruminal digestion. Factors such as particle size and surface area for digestion may limit both ruminal fermentation and intestinal digestion processes.

The highest digestibility of feed N was with the 35 percent level of water (Table 3). Total microbial and feed N entering the duodenum tended to be highest with the 25 percent moisture treatment. Ruminal bypass of dietary protein (54 to 72 percent) exhibited a quadratic effect. Since protein is solubilized during the fermentation process, lower protein bypass for fermented grain was anticipated. All values were higher than expected for fermented corn grain and similar to previous estimates of 55 to 65 percent with dry corn grain. Possibly the nitrogen solubilized during fermentation is similar to the fraction which is normally digested in the rumen.

Ruminal and total tract digestibilities of fiber tended to decline with added moisture (Table 2). If ruminal fiber digestion is depressed, coarser fiber may accumulate in the rumen and depress feed intake.

Table 3. Effect of fermentation on nitrogen digestion and passage.

Item	Water percent 15	20	25	30	35
N intake, lb	.38[ab]	.42[a]	.37[ab]	.36[b]	.36[b]
Rumen NH_3, mg/100ml	21.3[b]	19.6	12.8	17.5[ab]	18.8[ab]
Duodenal N, lb	.31[b]	.39[a]	.40[a]	.36[ab]	.34[ab]
Adjusted duodenal N digestion, %	60.6	49.8	50.5	54.5	61.4
Protein bypass, %	54.2	69.6	72.1	66.6	56.3
Ileal N, lb	.14[ab]	.15[a]	.13[ab]	.14[ab]	.11[b]
Fecal N, lb	.12[ab]	.14[a]	.13[ab]	.13[b]	.09[a]
Total tract N dig, %	67.4[ab]	66.4[ab]	66.0[ab]	64.1[b]	73.4[a]

[ab]Means in a row with different superscripts differ (P<.05).

Cottonseed hulls can exit from the rumen without extensive disintegration. Hence, intake of water HMC in our previous experiments have not been depressed when hulls were used as the roughage. More feed intake problems might be expected with low quality roughages than necessitate greater disintegration for ruminal exit. Addition of buffers to increase ruminal pH and shorten fiber digestion lag time and(or) elevate rate of fiber digestion might prove useful with wetter HMC.

In summary, these results indicate that increasing moisture levels from 15 to 35 percent for fermentation aid in converting starch to a more available form. Duodenal entry of N of feed and microbial origin were maximal at the 25 percent water level. However, intermediate moisture levels slightly depressed ADF digestion which could have deleterious effects on feed intake in some situations. Further study of ruminal fiber digestion with HMC at high levels of feed intake is needed. In addition, this study should be reported with corn grain of a single variety harvested at different stages of maturity to determine if results are similar.