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Influence of Corn Hybrid and Processing Method on Digestibility and Ruminal Fermentation

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Summary

Three hybrids with different kernel traits and feeding value were selected from a previous study to determine effects of corn hybrid and processing method (high-moisture corn (HMC), or dry-rolled corn DRC)) on nutrient digestibility and ruminal fermentation. DMI, intake rate, and total time spent eating were greater for HMC than DRC. Changes in ruminal pH and pH variance were also greater for HMC compared to DRC. Total-tract nutrient digestibility was influenced by processing method and hybrid. Nutrient digestibilities were greatest for hybrid 1, and greater for HMC compared to DRC. There was a hybrid by processing method interaction for molar proportions of propionate and the acetate: propionate (A:P) ratio. The magnitude of change for propionate molar proportions and the A:P ratio were different among hybrids when fed as HMC compared to DRC. Selection of hybrids with softer kernel traits and use of HMC will result in greater digestibility and favorable ruminal fermentation end products such as propionate.

Introduction

A greater extent of starch digestion is ideal for feedlot producers to maximize efficiency if acidosis can be controlled. The primary way to increase the extent of starch digestion for high-moisture and dry-rolled corn is to increase the rate of degradation in the rumen. Another way producers can maximize efficiency is by selecting hybrids with kernel traits that are associated with improved digestibility when fed as dry-rolled corn (*2004 Nebraska Beef Report,* pp. 54-57). Altering kernel traits of hybrids using more intense processing methods such as high-moisture ensiling, fine grinding, or steam-flaking may take away the advantage of selecting hybrids with more desirable kernel traits (*2003 Nebraska Beef Report,* pp. 32-34). However, a more intense processing method may also increase the incidence of acidosis and reduce feed efficiency if starch fermentation is too rapid. Therefore, the objectives of our research were to 1) determine total-tract nutrient digestibility, 2) monitor intake patterns and ruminal pH, and 3) determine ruminal volatile fatty-acid concentrations of steers fed three hybrids with varying kernel traits and feeding value processed as either dry-rolled or high-moisture corn.

Procedure

Six ruminally cannulated steers (BW= 960 lb) were used in a 6x6 Latin square to determine digestibility of hybrids fed as dry-rolled (DRC) or high-moisture corn (HMC) . Treatments consisted of three hybrids: H-8562 (1), 33P67 (2), and H-9230Bt (3); processed either as DRC or HMC in a 3x2 factorial arrangement. Dry-rolled corn was coarsely rolled and reconstituted to 28% moisture to mimic early harvested HMC. Diets consisted of 68.5% corn, 20% wet corn gluten feed, 7.5% alfalfa, and 4% supplement. In a previous study (*2004 Nebraska Beef Report,* pp. 54-57), F:G was 5.45 for hybrid 1, 5.62 for hybrid 2, and 5.95 for hybrid 3. Laboratory analyses indicate hybrid 1 has the largest/softest kernels, hybrid 3 the hardest/smallest kernels, and hybrid 2 was intermediate for both kernel hardness and size. Steers were fed for ad libitum intake once daily at 0730.

Periods were 14 days in length with a 9-day adaptation to the diet, and a 5-day collection period to measure digestibility, ruminal fermentation, pH, and intake. Steers were individually fed in pens during the adaptation on days 1-8 and moved into stantions for the collection period on day 9. Feed intake patterns and ruminal pH measurements were collected (days 10 to 14) as described in the *1998 Nebraska Beef Report,* pp. 71-75 . Feed intake measurements included DMI, intake rate, number of meals per day, and total time spent eating. The ruminal pH parameters measured were average pH, pH change, pH variance, and maximum and minimum pH.

Chromic oxide was used as an indigestible marker for estimating fecal output. Boluses were administered via rumen cannula twice daily at 0700 and 1900 with each dose containing 7.5 grams chromic oxide. Fecal grab samples were collected three times daily on days 10 through 14 at 0, 6, and 12 hours post-feeding. Feed ingredients, feed refusals, and fecal samples were freeze-dried and analyzed to calculate nutrient digestibility. Ruminal fluid samples were collected on day 14 of each period prior to feeding, and every two hours post-feeding for a 12-hour period to determine volatile fatty acid (VFA) concentrations.

Results

Dry matter, organic matter, and starch intake were similar among hybrids. Interestingly, nutrient intake was greater ($P < 0.02$) for animals consuming HMC compared to DRC (Table 1). Total time spent eating and intake rate were also greater ($P < 0.05$) for animals consuming HMC compared to DRC. Average meal size and number of meals/day were not different ($P > 0.05$) among processing methods or hybrids and averaged 3.9 lb/meal and 7.2 meals/day, respectively.

Total tract nutrient digestibilities were influenced by both hybrid and

Table 1. Effect of corn hybrid and processing method on intake and nutrient digestibility.

	Dietary Treatment[a]									
	DRC			HMC				*P*-value[c]		
Item	1	2	3	1	2	3	SEM[b]	Process	Hybrid	Inter
Nutrient Digestibility										
Dry Matter										
Intake, lb/day	20.8	22.7	22.2	23.3	23.5	23.2	0.8	< 0.01	0.19	0.28
Digestibility, %	79.8	74.1	76.5	80.5	77.7	78.3	2.1	0.10	0.03	0.63
Organic Matter										
Intake, lb / day	16.7	19.2	18.0	20.3	19.7	19.2	1.2	0.02	0.45	0.18
Digestibility, %	79.9	74.4	76.3	82.5	78.4	79.0	2.5	0.05	0.04	0.91
Starch										
Intake, lb/day	9.2	9.7	9.3	10.8	10.6	10.3	0.6	< 0.01	0.68	0.67
Digestibility, %	96.1	95.1	95.3	97.0	96.0	95.8	0.5	0.02	0.02	0.80
Intake Patterns										
No. Meals/day	7.5	6.2	7.0	7.6	7.2	7.4	0.5	0.12	0.15	0.50
Total time (min)	566	533	558	613	631	647	37	< 0.01	0.72	0.58
Rate, %/hour	12.7	13.5	15.1	17.4	15.2	17.4	2.3	0.04	0.51	0.63

[a]Hybrids consisted of Golden Harvest H-8562 (1), Pioneer 33P67 (2), and Golden Harvest H-9230Bt (3); processed as dry-rolled corn (DRC) or high-moisture corn (HMC).
[b]SEM = Standard error of the mean for the hybrid by processing method interaction.
[c] Process = Main effects of dry-rolling versus high-moisture ensiling: Hybrid = main effect of hybrid; Inter = interaction of processing method and hybrid.

Table 2. Effect of corn hybrid and processing method on ruminal pH and VFA concentration.

	Dietary Treatment[a]									
	DRC			HMC				*P*-value[c]		
Item	1	2	3	1	2	3	SEM[b]	Process	Hybrid	Inter
Ruminal pH										
Average	5.58	5.59	5.78	5.65	5.66	5.53	0.12	0.58	0.91	0.10
Maximum	6.24	6.20	6.36	6.49	6.32	6.25	0.13	0.24	0.53	0.15
Minimum	5.13	5.13	5.31	5.03	5.15	4.89	0.16	0.08	0.83	0.15
pH change	1.11	1.07	1.05	1.46	1.17	1.36	0.15	< 0.01	0.31	0.45
pH variance	0.048	0.044	0.043	0.098	0.068	0.082	0.003	< 0.01	0.38	0.62
Ruminal VFA										
Acetate, mM	50.6	52.9	52.0	49.8	49.1	48.1	2.1	0.02	0.79	0.47
Molar %	48.5	48.6	50.2	44.2	46.5	45.5	1.4	< 0.01	0.25	0.33
Propionate, mM	38.0	36.1	30.1	48.0	41.9	46.4	3.2	< 0.01	0.07	0.06
Molar %	36.2[ef]	33.5[f]	28.6[g]	46.2[d]	39.7[e]	44.5[d]	2.4	< 0.01	< 0.01	< 0.01
A:P	1.41[f]	1.45[f]	2.06[g]	0.76[d]	1.20[ef]	1.08[e]	0.1	< 0.01	< 0.01	< 0.01
Butyrate, mM	9.2[de]	12.8[fg]	15.8[g]	7.4[de]	10.2[ef]	6.7[d]	1.8	< 0.01	0.02	< 0.01
Total VFA, mM	104.8	108.8	105.5	104.4	110.5	106.0	3.9	0.69	0.57	0.23

[a]Hybrids consisted of Golden Harvest H-8562 (1), Pioneer 33P67 (2), and Golden Harvest H-9230Bt (3); processed as dry-rolled corn (DRC) or high-moisture corn (HMC).
[b]SEM = Standard error of the mean for the hybrid by processing method interaction.
[c]Process = Main effects of dry-rolling versus high-moisture ensiling: Hybrid = main effect of hybrid; Inter = interaction of processing method and hybrid.
[d,e,f,g]Significant hybrid by processing method interaction. Means within row with unlike superscripts differ ($P < 0.05$).

processing method (Table 1). DM and OM digestibility for hybrid 1 were greater ($P < 0.04$) than for hybrid 2, and tended ($P = 0.07$) to be greater than hybrid 3. Starch digestibility was also greater (P = 0.02) for hybrid 1 compared to hybrids 2 and 3. DM digestibility tended ($P = 0.10$) to be greater for HMC than DRC. OM and starch digestibility were greater ($P = 0.05$ and $P = 0.02$, respectively) for HMC than DRC.

There was a tendency ($P = 0.10$) for a hybrid by processing method interaction for average pH (Table 2). Animals consuming hybrids 1 and 2 as HMC had a higher average pH than for those fed the same hybrid as DRC. Conversely, average pH for animals consuming hybrid 3 had a lower pH when fed as HMC. Overall, the average pH for HMC and DRC was 5.61, and 5.65, respectively. The change in pH (maximum to minimum) and pH variance were greater ($P < 0.05$) for HMC than DRC, indicating that a more intense processing method has a more rapid fermentation rate than DRC. There was also a tendency ($P = 0.08$) for minimum pH to be lower for HMC than DRC. One explanation for ruminal pH to be similar for animals consuming HMC and DRC could be due to more total time spent eating, and a tendency ($P = 0.12$) for animals consuming HMC to eat more meals/day. The intake behavior could be due to the animal regulating its intake so they do not experience acidosis. Consuming a smaller quantity of feed more often and allowing

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ruminal pH to recover between meals could contribute to a similar average pH for both processing methods. Even though the addition of WCGF to these diets mediated the pH, there is enough fermentable starch in the DRC diets for animals to experience acidosis. These animals also regulate intake similar to those consuming HMC diets but do not experience the changes in ruminal pH as rapidly (variance) or to the same extent (pH change).

Ruminal fluid analyses indicate differences existed among hybrids and processing methods for VFA concentrations (Table 2). There was a hybrid by processing method interaction for molar proportions (%) of propionate, and the acetate: propionate (A:P) ratio. The increase in molar% of propionate for HMC compared to DRC for hybrid 3 was greater than the increase for hybrids 1 and 2. The larger increase in the molar % of propionate suggests the harder kernel traits for hybrid 3 could have limited rumen degradation when fed as DRC. These data are similar to the VFA measurements taken in a previous study (*2005 Nebraska Beef Report,* pp. 34-36) where propionate concentrations were the lowest for hybrid 3 (H-9230Bt) when fed as DRC. Through high-moisture ensiling, these kernel traits were altered allowing for a greater increase in propionate concentrations. The decrease in the A:P ratio from DRC to HMC for hybrids 1 and 3 were greater than the decrease for hybrid 2. The smaller decrease in the A:P ratio for hybrid 2 is due to the smaller change found for the concentration of propionate when fed as HMC compared to DRC.

A processing method by time interaction ($P < 0.01$) existed for molar % of propionate and the A:P ratio. Molar % of propionate for animals consuming DRC averaged 32.8% and did not change throughout the sampling day (data not shown). The molar % of propionate for animals consuming HMC were 34.6% prior to feeding and increased throughout the sampling day to 46.3% 12 hours after feeding.

Nutrient digestibility data show hybrid 1 maintained an advantage over hybrids 2 and 3 even though a more intense processing method was used. The differences found for total-tract nutrient digestibility and VFA concentrations for hybrids fed as either DRC or HMC may have efficiency implications for hybrid selection and processing method. Producers feeding corn as DRC may want to consider selecting hybrids with larger, softer kernels. If a more intense processing method is used such as high-moisture ensiling, hybrid selection may not be as important.

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