Evaluation of Processing Technique for High-Moisture and Dry Corn on Nutrient Digestion when fed to Finishing Cattle

Caitlin A. Coulson
Mitch M. Norman
Nicole M. Woita
Hannah C. Wilson
Kylie M. Butterfield
Tyler J. Spore
Galen E. Erickson

Summary with Implications

A digestion trial was conducted to determine the effect of corn milling method when processing dry or high-moisture corn on nutrient digestion. Treatments were evaluated as a 2 × 2 factorial with the first factor as corn type [dry corn or high-moisture corn] and second factor as mill type [roller mill or hammer mill]. Feeding high-moisture corn decreased the amount of excreted dry matter and organic matter regardless of processing method, but there tended to be an interaction between corn type and milling method for digestibility. There was no difference between milling treatments fed as high-moisture corn, but hammer milled dry corn was more digestible than dry rolled corn. Cattle fed high-moisture corn based diet had greater starch digestibility compared to dry corn, but milling method had no impact. There was no difference in average pH, but feeding high-moisture corn diets resulted in greater variance and greater area under pH 5.6 compared to dry corn diets. Overall, feeding cattle high-moisture compared to dry corn increased nutrient digestibility, but milling method had limited impact.

Introduction

Corn processing is utilized in feedlot finishing diets to increase starch digestion and improve feed conversion. For dry and high-moisture corn fed to cattle, a hammer mill or roller mill are the most common methods for processing corn in Nebraska. Although each method is sufficient at processing grains, each method has unique advantages and disadvantages. Hammer mills are generally more cost effective and require less dollars to maintain; but are energetically inefficient. Roller mills are more expensive to buy and maintain; however, they tend to be more energy efficient to operate.

A performance study previously evaluated the effect of feeding dry corn (DC), high-moisture corn (HMC), or a blend of DC:HMC to cattle processed using either a roller mill (ROLL; Automatic Ag, Pender) or hammer mill (HAMMER) and concluded that cattle fed ROLL HMC were approximately 5% more efficient than steers fed HAMMER HMC (*2021 Nebraska Beef Cattle Report*, pp 46–49). Thus, the objective of this experiment was to evaluate the effect of feeding dry or high-moisture corn processed with a hammer mill or roller mill in diets containing 20% modified distillers grains plus solubles (MDGS) on nutrient digestion and rumen characteristics.

Table 1. Composition (DM basis) and chemical analysis of diet comparing dry corn (DC) to high-moisture corn (HMC) using either a roller (ROLL) or hammer mill (HAMMER).

	ROLL		HAMMER	
	DC	HMC	DC	HMC
Dry corn	70	-	70	-
High-moisture corn	-	70	-	70
Modified Distillers plus Solubles	20	20	20	20
Corn stalks, ground	5	5	5	5
Supplement [1]				
Urea	0.5	0.5	0.5	0.5
Chemical Composition				
CP, %	14.6	14.7	14.6	14.6
Ca, %	0.65	0.65	0.65	0.66
P, %	0.41	0.39	0.41	0.37
NDF, %	17.1	16.4	18.0	16.6
ADF, %	7.40	7.72	7.28	7.61
Starch, %	53.0	52.0	52.3	52.0

[1] Supplement formulated to contain 30 g/ton monensin (Rumensin, Elanco Animal Health) diet DM, and provide 90 mg/steer daily of tylosin (Tylan, Elanco Animal Health). Supplement contained limestone, vitamins ADE, and trace mineral package to meet all mineral and vitamin requirements.

Materials and Methods

Seven ruminally fistulated steers were used in a 4 × 7 incomplete, replicated Latin square, with each steer assigned randomly to each dietary treatment once for 4 consecutive, 21-d periods. Periods allowed for 14 d of adaptation, followed by 7 d of collections. Treatment design was a 2 × 2 factorial design, with DC or HMC processed with a roller mill (ROLL) or hammer mill (HAMMER). Diets were mixed twice weekly and stored in a cooler (4° C) to ensure freshness. Experimental diet included (Table 1): 70% corn, 20% modified distillers grains plus solubles, 5% corn stalks, and 5% supplement. Supplement was formulated

Table 2. Diet intake, total tract digestibility, and ruminal pH parameters for steers fed dry corn (DC) to high-moisture corn (HMC) using either a roller (ROLL) or hammer mill (HAMMER).

	ROLL[1]		HAMMER			*P*-Value[2]		
Item	DC	HMC	DC	HMC	SEM	Grain	Mill	Int.
Dry Matter								
Intake, lb/d	19.5	17.3	19.3	18.0	1.42	0.20	0.85	0.74
Digestibility, %	76.4[b]	83.3[a]	80.0[a]	82.9[a]	2.54	<0.01	0.22	0.13
Organic Matter								
Intake, lb/d	18.8	16.7	18.7	17.3	1.37	0.20	0.85	0.77
Digestibility, %	77.7[c]	85.3[a]	81.5[b]	84.5[ab]	2.39	<0.01	0.26	0.10
Starch								
Intake, lb/d	9.76	8.52	9.23	9.38	0.703	0.43	0.81	0.30
Digestibility, %	91.5	99.0	93.7	98.4	1.21	<0.01	0.56	0.29
Energy								
DE Intake, Mcal/lb	1.49[b]	1.68[a]	1.56[b]	1.67[a]	0.049	<0.01	0.29	0.13
DE, % of GE	76.3[c]	83.9[a]	80.0[bc]	83.6[ab]	2.53	<0.01	0.22	0.15
Ruminal pH								
Minimum pH	5.27[a]	5.03[b]	5.08[ab]	5.15[ab]	0.106	0.34	0.39	0.07
Maximum pH	6.46	6.55	6.39	6.45	0.159	0.58	0.51	0.93
Average pH	5.73	5.54	5.54	5.60	0.149	0.56	0.61	0.27
pH Variance	0.082	0.141	0.096	0.110	0.0205	0.04	0.61	0.18
Time < 5.6, min/d	747	900	853	972	145.2	0.27	0.47	0.89
Area < 5.6	156	324	245	390	79.6	0.05	0.33	0.88

[a, b, c] Values within a row without common superscripts differ ($P \leq 0.10$)

[1]Treatments were corn processed with a roller mill (ROLL) or hammer mill (HAMMER) and fed as dry corn (DC) or high-moisture corn (HMC).

[2] Grain = *P*-value associated with the main effect of grain type, Mill = *P*-value associated with main effect of milling method, Int = *P*-value associated with grain × mill

to provide 30 g/ton monensin (Rumensin, Elanco Animal Health), 90 mg/steer daily of tylosin (Tylan, Elanco Animal Health), 0.5% urea, calcium, salt, trace mineral, and vitamins to meet or exceed steer requirements. Cattle were adapated to new diets between periods by blending the diet from the previous period with the diet for the new period over the course of 5 d. Ingredients were sampled twice during each 21-d period and analyzed for DM using a 60°C forced-air oven to ensure proper formulation of treatment diets. Feed refusals were collected from d 16 to 21, subsampled, DM determined, and intakes were corrected.

Titanium dioxide was ruminally dosed at a rate of 5.0 g/steer twice daily at 0700 and 1700 for 7 d before and for the duration of the collection period. Fecal grab samples were collected three times daily on d 17–21 and composited into 1-d samples. Fecal samples were freeze-dried, ground through a 1-mm screen, and composited by animal within period for analysis of neutral detergent fiber (NDF), acid detergent fiber (ADF), DM, OM, TiO_2 for total fecal DM output, and starch. Diet ingredient samples were also composited into period samples and analyzed for NDF, ADF, DM, OM, and starch concentration. Ruminal pH probes were inserted in the rumen on d 14 and recorded pH every minute until removal on d 21. Rumen pH data were analyzed for d 16–20. Data were analyzed using the MIXED procedure of SAS with fixed effect of treatment and period, and steer treated as a random effect. Ruminal pH data were also analyzed using MIXED procedure of SAS and day was included as a repeated measure. Treatment differences were considered significant when $\alpha \leq 0.05$ and a tendency was considered when $0.05 < \alpha \leq 0.15$.

Results

There were no interactions ($P \geq 0.18$; Table 2) between corn type and milling method for total tract DM intake, OM intake, NDF intake or NDF digestibility. There tended to be an interaction ($P = 0.13$) between corn type and milling method for total tract DM digestibility, resulting from a larger increase in DM digestibility for HMC compared to DC when rolled (6.9 percentage units) compared with hammer mill (2.9 percentage units). Organic matter digestibility followed the same trend ($P = 0.10$) with a more dramatic increase in OM digestion for ROLL HMC than ROLL DC (7.6 percentage units) compared to corns processed with HAMMER (3.0 percentage units). Feeding HMC processed either way was similar in total tract OM digestibility and averaged 85%. Digestibility of OM was lower for dry corns, but HAMMER was greater than ROLL.

There were no interactions ($P \geq 0.27$) for starch intake or digestibility. Feeding HMC increased total tract starch digestion compared to DC ($P < 0.01$). High-moisture corn diets had the greatest digestible energy intake (Mcal/lb DM) regardless of processing method; however, processing HMC compared with DC with ROLL increased digestible energy intake at a greater magnitude compared with HAMMER, resulting in a tendency ($P = 0.13$) for an interaction. There was a tendency ($P = 0.07$) for an interaction for minimum pH; ROLL HMC had a lower pH than ROLL DC but HAMMER HMC had a greater than ROLL DC. There was no effect ($P \geq 0.27$) due to milling method or corn type for average or maximum pH. Feeding HMC resulted in greater pH variance and area below a pH of 5.6 ($P < 0.05$) compared to DC.

Conclusion

Results suggest that feeding HMC increases DM, OM, and starch digestibility, but mill type has limited effect on nutrient digestibility. Processing corn with ROLL resulted in a greater magnitude of change when fed as high-moisture corn compared to dry corn, resulting in a tendency for an interaction between grain type and mill type for DM and OM digestibility and digestible energy intake. Furthermore, there was limited effect on ruminal pH for corn type or milling method. Overall, feeding HMC increases nutrient digestibility compared to DC, but milling method had limited effect.

Caitlin A. Coulson, graduate student

Mitch M. Norman, research technician

Nicole M. Woita, graduate student

Hannah C. Wilson, research technician

Kylie M. Butterfield, graduate student

Tyler J. Spore, research technician

Galen E. Erickson, professor; University of Nebraska, Animal Science, University of Nebraska–Lincoln