Evaluation of Processing Technique for High-Moisture and Dry Corn Fed to Finishing Cattle

C. A. Coulson
B. M. Boyd
B. C. Troyer
L. J. McPhillips
M. M. Norman
G. E. Erickson

Summary with Implications

A 134-day finishing trial was conducted to evaluate the effect of milling method and corn type on finishing cattle performance and carcass characteristics. Treatments were applied in a 2 × 3 factorial arrangement, with the first factor as milling method (Automatic Ag roller mill or hammer mill) and the second factor as corn type, either 100% dry corn, 50:50 blend of dry and high moisture corn, or 100% high moisture corn. There was no interaction between milling method and corn type for carcass-adjusted final body weight, average daily gain, or dry matter intake but there was an interaction between milling method and corn type for feed conversion. Cattle fed the diet containing 100% high moisture corn processed with the Automatic Ag roller mill were 4.7% more efficient than cattle fed a 100% high moisture corn-based diet processed with a hammer mill. There was no effect on carcass characteristics based on milling method or corn type. Processing high-moisture corn using Automatic Ag's roller mill improved feed conversion compared to processing with a hammer mill, but processing method had little effect on dry corn or blended diets.

Introduction

Corn is processed in feedlot finishing diets to increase starch digestion and improve feed conversion. While the effect of corn processing method has been extensively studied, prior research was conducted before the widespread use of distillers grains plus solubles in finishing diets. Therefore, the objective of this experiment was to evaluate the effect of using Automatic Ag roller mill or a hammer mill to process dry corn or high-moisture corn in diets containing 20% wet distillers grains plus solubles (WDGS).

Table 1. Composition (DM basis) of diets fed to steers to evaluate the effect of processing technique and corn type on animal performance and carcass characteristics.

	Auto Ag Roller Mill			Hammer Mill		
	DC	DC:HMC	HMC	DC	DC:HMC	HMC
Dry corn	70	35	-	70	35	-
High-moisture corn	-	35	70	-	35	70
Wet Distillers + Solubles	20	20	20	20	20	20
Corn Stalks, ground	5	5	5	5	5	5
Supplement [1]	5	5	5	5	5	5

[1] Supplement formulated to provide 390 mg/steer daily of monesin, 90 mg/steer daily of tylosin, and a vitamin + trace mineral package

Table 2. Particle size distribution by percentage for dry corn (DC) and high moisture corn processed by Automatic Ag (AA) roller mill or hammer mill

	AA Roller Mill		Hammer Mill	
Screen Size, µm	DC	HMC	DC	HMC
6300	1.7	9.7	10.9	30.1
4750	29.5	34.5	8.3	18.7
3350	39.8	26.1	15.8	22.2
1700	23.8	17.3	29.0	20.9
1410	1.3	2.1	11.6	2.1
850	1.7	3.8	8.5	2.9
600	0.5	2.0	5.3	1.1
<600	1.7	4.5	10.7	1.7
Geometric mean diameter, µm	3514	2867	1808	2248
Geometric standard deviation, µm	1160	1335	924	501

Materials and Methods

A feedlot study was conducted at the Eastern Nebraska Research and Extension Center (ENREC) near Mead, NE. Crossbred steers (n=600; initial BW = 885 lb; SD = 37 lb) were used in an experiment with a 2 × 3 factorial design. Factors consisted of two milling methods (roller mill or hammer mill) and corn fed one of three ways [100% dry corn, 50:50 blend, or 100% high-moisture corn (HMC)] for a total of 60 pens with 10 replications per treatment and 10 steers/pen. The roller mill (Automatic Ag, Pender, NE) was used for both dry and high-moisture corn and two hammer mills were used: Haybuster (Jamestown, ND) for high-moisture corn and Might Giant Tub Grinder (Jones Manufacturing, Beemer,

Table 3. Simple effects of milling method and corn type on performance and carcass characteristics of finishing steers

	Auto Ag Roller Mill			Hammer Mill							
	DC	DC:HMC	HMC	DC	DC:HMC	HMC	SEM	Corn Type P-Value	Mill Type P-Value	Corn x Mill Type	Roller vs Hammer HMC
Initial BW, lb	884	884	884	886	884	887	1.0	0.35	0.03	0.54	0.08
Carcass-Adj. Performance											
Final BW, lb[1]	1483	1478	1483	1486	1479	1464	9.0	0.44	0.44	0.35	0.10
DMI, lb/d	28.6	27.9	26.4	28.8	27.9	26.7	0.28	<0.01	0.46	0.86	0.46
ADG, lb	4.49	4.46	4.49	4.49	4.46	4.32	0.07	0.42	0.32	0.32	0.07
F:G	6.37^{bc}	6.25^{bc}	5.88^{a}	6.41^{c}	6.25^{bc}	6.17^{b}	-	<0.01	0.07	0.09	<0.01
NEm, mcal/lb[2]	0.84	0.86	0.90	0.84	0.86	0.87	0.008	<0.01	0.07	0.10	<0.01
NEg, mcal/lb	0.55	0.57	0.61	0.55	0.57	0.58	0.007	<0.01	0.04	0.16	<0.01
ME, mcal/lb	1.27	1.28	1.34	1.27	1.28	1.30	0.010	<0.01	0.06	0.10	<0.01
Carcass Characteristics											
HCW, lb	934	932	935	936	932	922	5.7	0.45	0.43	0.34	0.10
Dressing Percent	61.8	62.4	62.4	62.0	62.3	61.8	0.24	0.18	0.40	0.25	0.08
LM area, in sq.	14.3	14.6	14.7	14.6	14.7	14.6	0.17	0.29	0.46	0.31	0.52
Marbling score[3]	484	515	475	488	477	474	10.7	0.12	0.18	0.09	0.99
12th rib fat thickness, in.	0.53	0.52	0.51	0.50	0.51	0.50	0.02	0.93	0.14	0.66	0.64
Calculated YG [4]	3.29	3.10	3.09	3.20	3.15	3.10	0.06	0.05	0.50	0.52	0.86
Liver Abscess, %	28	27	38	24	29	27	5.8	0.19	0.43	0.37	0.13

[a, b, c] Means within a row and without common superscripts differ ($P \le 0.05$)

[1] Final BW adjusted to a common dressing percent of 63%

[2] Values calculated using equations from Galyean et al. and are based on intake and performance of cattle

[3] 400 = small, 500 = modest, 600=moderate

[4] Yield grade = 2.5 + (2.5 * BF, in)—(0.32 * LM area, in^2) + (0.2 * 2.5, KPH %) + (0.0038 * HCW, lb) where KPH is assumed to be 2.5%.

NE) for dry corn. Both HMC and dry corn were processed using a 5/8" screen in the hammer mill, and the roller mill was adjusted as needed to ensure all kernels were broken. High moisture corn was harvested and processed in September 2018 and kept in a bunker until trial initiation in May of 2019. Dry corn was processed as needed throughout the feeding period. Before trial initiation, cattle were limit-fed a common diet consisting of 50% Sweet Bran (Cargill, Blair, NE) and 50% alfalfa hay for 5 consecutive days to minimize BW variation due to gut fill. Cattle were weighed on two consecutive days and averaged to establish initial BW. Blocking criteria were related to start time and BW. Two BW blocks were used in the first start block (4 reps in light block and 1 rep in heavy block) and 1 BW block in the second start block, resulting in three total blocks. Cattle were fed ad libitum once daily at approximately 0800. Cattle were adapted to finishing rations over 23 days with corn replacing alfalfa hay [32.5% corn and 37.5% alfalfa hay (DM-basis), initially, with corn replacing alfalfa in 10% (DM-basis) increments]. All finishing diets included (DM-basis; Table 1): 70% corn (DC, 50:50 blend, or HMC), 20% wet distillers grains plus solubles, 5% ground corn stalks and 5% supplement. The supplement was formulated to provide 90 mg/steer tylosin, 390 mg/ steer monensin daily (30 g/ton of DM concentration), and 0.5% urea in the diet as well as a calcium, salt, vitamin and trace minerals to meet or exceed requirements.

Cattle were implanted with Revalor-IS (80 mg trenbolone acetate + 16 mg estradiol; Merck Animal Health) on d 1 and reimplanted with Revalor-200 (200 mg trenbolone acetate + 20 mg estradiol; Merck Animal Health) on d 50. Steers were fed for 134 days and harvested at a commercial abattoir (Greater Omaha Packing, Omaha, NE). Hot carcass weight and liver score were recorded on harvest date, and LM area, USDA marbling score, and fat depth were collected following a 48-hour chill using camera data. Final live BW was calculated using the pen average final live BW pencil shrunk 4% to adjust for fill. Carcass-adjusted performance was calculated by dividing hot carcass weight by a common dressing percentage of 63%.

Samples of dry corn and HMC were taken at trial initiation and reimplant time and used for particle size determination. Samples were used to determine corn particle size distribution, geometric mean diameter, and geometric standard deviation for each processing method.

Data were analyzed as a 2 3 factorial design with the main effects of mill type and corn type and the appropriate interaction. The MIXED procedure of SAS was

Table 4. Main effect of corn type on steer performance and carcass characteristics

	DC	DC:HMC	HMC	SEM	Corn Type P-Value
Initial BW, lb	885	884	885	0.8	0.35
Carcass-Adj. Performance					
Final BW, lb [1]	1484	1479	1473	6.7	0.44
DMI, lb/d	28.7^{a}	27.9^{b}	26.5^{c}	0.21	<0.01
ADG, lb	4.49	4.46	4.41	0.05	0.42
Live Performance					
Final BW, lb	1510^{a}	1497^{ab}	1495^{b}	5.6	0.07
Dressing percent	61.9	62.2	62.1	1.9	0.18
NEm, mcal/lb[2]	0.84^{b}	0.86^{b}	0.89^{a}	0.005	<0.01
NEg, mcal/lb	0.55^{c}	0.57^{b}	0.59^{a}	0.005	<0.01
ME, mcal/lb	1.27^{b}	1.28^{b}	1.32^{a}	0.007	<0.01
Carcass Characteristics					
HCW, lb	935	932	928	4.2	0.45
LM area, in sq.	14.4	14.7	14.6	0.12	0.29
Marbling score [3]	486	496	474	7.9	0.12
12th rib fat thickness, in.	0.51	0.51	0.51	0.011	0.93
Calculated YG [4]	3.24^{b}	3.12^{ab}	3.09^{a}	0.048	0.05
Liver Abscess, %	26	28	33	4.0	0.19

[a, b, c] Means within a row and without common superscripts differ ($P \leq 0.05$)

[1] Final BW adjusted to a common dressing percent of 63%

[2] Values calculated using equations from Galyean et al. derived from the NRC (1996) and are based on intake and performance of cattle

[3] 400 = small, 500 = modest, 600=moderate

[4] Yield grade = 2.5 + (2.5 * BF, in.)—(0.32 * LM area, in^2) + (0.2 * 2.5, KPH %) + (0.0038 * HCW, lb.) where KPH is assumed to be 2.5%.

used for performance and carcass characteristics with start block and treatment as fixed effects. Liver data were analyzed using GLIMMIX as a binomial distribution. Alpha values of ≤ 0.05 were considered significant and $0.05 \leq \alpha \leq 0.10$ was considered a tendency.

Results

As expected, the Automatic Ag roller mill had a numerically greater geometric mean diameter and a greater percentage of particles retained on sieves greater than 1700 µm, but less than 6300 µm (whole kernel) compared to the hammer mill (Table 2). The average weekly DM of the roller HMC and DC were 68.2% and 90.0%, respectively, and the average DM of the hammer mill HMC and DC were 65.4% and 89.6% for the duration of the feeding period. Weekly ingredient DM were adjusted weekly to correct % of diets on an as-fed basis when loaded to ensure accuracy for DM inclusions.

There were no interactions between corn type × milling method (Table 3) for carcass-adjusted final weight, DMI, or ADG ($P \geq 0.32$), but there was a tendency for an interaction between corn type and milling method for feed conversion ($P = 0.09$). Steers fed the HMC diet processed with the roller mill had an improvement of feed efficiency of 4.7% ($P < 0.01$) over HMC processed with the hammer mill. The DC:HMC blended diets processed with either mill type and DC diets processed with the roller mill were intermediate, but not different than DC processed with the hammer mill. This F:G response is further explained by a tendency between corn type and milling method for NEm and metabolizable energy ($P = 0.10$; Table 3). There were no interactions between corn type × milling method for HCW, dressing percent, LM area, 12th rib fat thickness, calculated yield grade, or liver abscess percent ($P \geq 0.25$), but there was a tendency for an interaction between corn type and milling method for USDA marbling score ($P = 0.09$). It is important to note that there was a high incidence of liver abscesses in this trial suggesting that cattle were challenged from an acidosis perspective as anticipated with a high concentrate ration. The lack of significant differences across treatments suggests acidosis is not influencing treatments outcomes. Due to the lack of an interaction for many variables, main effects of corn type and milling method are presented except for feed conversion.

There were no significant differences in final BW or ADG ($P \geq 0.42$) when evaluated on a carcass basis (corrected to common dressing percent of 63%) based on corn type (Table 4). Cattle fed the DC based diet had the greatest DMI ($P < 0.01$), the DC:HMC blended diet was intermediate and the HMC cattle had the lowest DMI. The differences in DMI are likely due to energy content (HMC being greater than dry corn) and greater acidosis potential of the HMC. Evaluating performance on a carcass-adjusted basis is more repeatable and estimating final weight from carcass weight is a better method for comparison of treatments. It appears gut fill lead to an increase in final live BW for cattle fed dry corn which was not translated to better carcass weight, thus lower dressing percent. High-moisture corn diets provided significantly more dietary energy in the diets ($P \leq 0.01$) compared to DC:HMC or DC alone (Table 4). There were no differences due to corn type for HCW, dressing percent, LM area, USDA marbling score, 12th rib fat thickness, or liver abscess percent ($P \geq 0.12$); however, steers fed HMC diets had a lower ($P = 0.05$) calculated YG compared to DC, but neither treatment differed from DC:HMC.

There was no effect on carcass-adjusted final BW, ADG, or DMI based on mill type ($P \geq 0.15$; Table 5). Diets processed with the roller mill had greater NEg ($P = 0.04$), and there was a tendency for the roller mill diets to have greater NEm and ME ($P \leq 0.07$) compared to processing with the hammer mill (Table 5). There was no effect of milling method on carcass characteristics ($P \geq 0.14$).

Table 5. Main effect of milling method on steer performance and carcass characteristics

	Auto Ag Roller Mill	Hammer Mill	SEM	Mill Type P-Value
Initial BW, lb	884	885	0.65	0.03
Carcass-Adj. Performance				
Final BW, lb [1]	1482	1476	5.7	0.44
DMI, lb/d	27.6	27.8	0.17	0.46
ADG, lb	4.48	4.42	0.042	0.32
Live Performance				
Final BW, lb	1502	1499	4.7	0.65
Dressing percent	62.2	62.0	1.6	0.40
NEm, mcal/lb[2]	0.87	0.86	0.005	0.07
NEg, mcal/lb	0.58	0.57	0.005	0.04
ME, mcal/lb	1.30	1.28	0.005	0.06
Carcass Characteristics				
HCW, lb	933	930	3.6	0.43
LM area, in sq.	14.5	14.6	0.10	0.46
Marbling score [3]	491	480	6.8	0.18
12th rib fat thickness, in.	0.52	0.50	0.010	0.14
Calculated YG [4]	3.16	3.15	0.041	0.50
Liver Abscess, %	31	27	4.0	0.43

[a, b, c] Means without common superscripts differ

[1] Final BW adjusted to a common dressing percent of 63%

[2] Values calculated using equations from Galyean et al. derived from the NRC (1996) and are based on intake and performance of cattle

[3] 400 = small, 500 = modest, 600=moderate

[4] Yield grade = 2.5 + (2.5 * BF, in.)—(0.32 * LM area, in^2) + (0.2 * 2.5, KPH %) + (0.0038 * HCW, lb.) where KPH is assumed to be 2.5%.

Conclusion

Overall, high-moisture corn processed with the roller mill improved feed conversion in finishing cattle by approximately 5% compared to hammer milling. Milling method also impacted particle size with less whole kernels in high-moisture corn processed with the roller mill and less small particles in dry corn processed with the Automatic Ag Roller Mill compared to hammer milling. Feeding high-moisture corn resulted in lower intake and similar gain, which improved feed conversion compared to dry corn, with DC:HMC being intermediate. Aside from the improved feed conversion by processing corn with the roller mill, there were no other impacts of milling method on cattle performance or carcass characteristics. Overall, these data suggest that processing high-moisture corn with the Automatic Ag roller mill improved conversion by approximately 5%.

Caitlin A. Coulson, graduate student

Bradley M. Boyd, research technician

Braden C. Troyer, research technician

Levi J. McPhillips, feedlot manager

Mitch M. Norman, assistant feedlot manager

Galen E. Erickson, professor, University of Nebraska–Lincoln