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Particle Size of Dry-rolled Corn Affects Starch Digestibility but Not Feedlot Performance

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Abstract

Dry-rolling corn is a common practice in feedlots located in the Midwestern and Northern Plains regions of the United States. Optimizing total digestive tract starch utilization in diets containing dry-rolled corn is essential for maximizing efficiency. However, recommendations often suggest that grain be coarsely cracked to avoid producing an excessive amount of fine material that could potentially increase the rate of fermentation, reduce rumen pH, and cause digestive disturbances.

Wet distillers byproducts may be effectively used as a protein and energy source for feedlot finishing cattle and can replace a portion of the dry-rolled corn in the diet. The average geometric mean particle size of dry-rolled corn across all feedyards ($n = 31$) was 0.179 ± 0.035 in. with a range of 0.085 to 0.269 in. The objective of this study was to evaluate the effects of dry-rolled corn particle size on animal performance, carcass traits, and starch digestibility in feedlot finishing diets containing 20% wet distillers grains on a dry matter basis.

Keywords

dry rolled corn, feedlot, particle size

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Introduction

Dry-rolling corn is a common practice in feedlots located in the Midwestern and Northern Plains regions of the United States. Optimizing total digestive tract starch utilization in diets containing dry-rolled corn is essential for maximizing efficiency. However, recommendations often suggest that grain be coarsely cracked to avoid producing an excessive amount of fine material that could potentially increase the rate of fermentation, reduce rumen pH, and cause digestive disturbances.

Wet distillers byproducts may be effectively used as a protein and energy source for feedlot finishing cattle and can replace a portion of the dry-rolled corn in the diet. The average geometric mean particle size of dry-rolled corn across all feedyards ($n = 31$) was 0.179 ± 0.035 in. with a range of 0.085 to 0.269 in. The objective of this study was to evaluate the effects of dry-rolled corn particle size on animal performance, carcass traits, and starch digestibility in feedlot finishing diets containing 20% wet distillers grains on a dry matter basis.

Key words: dry rolled corn, feedlot, particle size

Experimental Procedures

Cross-bred yearling steers ($n = 360$; initial body weight = 871 ± 79.0 lb) were used in a randomized complete block design to evaluate the effects of dry-rolled corn particle size in diets containing 20% wet distillers grains on feedlot performance, carcass characteristics, and starch digestibility.

Steers were individually weighed on 2 consecutive days and were divided into 9 weight block replicates, each consisting of 40 steers, and randomly allocated to one of 4 treatments. Steers were housed in 10-head feedlot pens where they received their dietary treatment throughout the duration of the study. Each pen measured 20×131 ft, contained a 73.2 ft² concrete feeding apron, 20 ft of bunk space, and each 2 adjacent pens shared a common continual flow water fountain. Pen was used as the experimental unit.

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Dietary treatments were coarse dry-rolled corn (0.192 in.), medium dry-rolled corn (0.148 in.), fine dry-rolled corn (0.093 in.), and steam-flaked corn (27 lb/bu). All diets contained 20% wet distillers grains (dry matter basis) and were formulated to meet or exceed National Research Council (2000) requirements for growing-finishing beef cattle. Steers were transitioned to the finishing diet over a 23-day period following arrival using a series of 4 diets including: starter (days 1-7), step-1 (days 8-14), step-2 (days 15-23), finisher without ractopamine hydrochloride (days 24-113), and finisher with ractopamine hydrochloride (days 114-142). Steam-flaked corn was used in the starter and step-up diets and all diet changes during the step-up program were simultaneous for all pens and all treatments. Optaflexx was fed to all treatments the final 29 days in the feedlot at 13.65 mg/lb dry matter basis, providing approximately 300 mg/head/day.

Particle size analysis was conducted weekly on dry-rolled corn samples. The average particle size within each sample is described as the geometric mean particle size and log normal standard deviation represents the range of particle size within each sample.

Fecal samples were analyzed for moisture, dry matter, and total starch content at the Kansas State University Ruminant Nutrition Laboratory using enzymatic hydrolysis. Samples were analyzed in duplicate and those samples which differed in total starch content between duplicates by 5% or greater were re-analyzed. Duplicates were averaged.

Two mature cross-bred steers (body weight \geq 1,598 lb), fitted with rumen cannula were fed gradually decreasing amounts of low-quality mixed grass hay and increasing amounts of the steam-flaked corn based finishing diet over a 14 day adaptation period followed by *ad libitum* amounts of the steam-flaked corn based finishing diet for an additional 7 days prior to the start of the *in situ* study. A 0.035 oz sample of unmasticated steam-flaked corn, coarse dry-rolled corn, medium dry-rolled corn, and fine dry-rolled corn samples were placed into separate Dacron bags and sealed. Four bags per time period (0, 2, 4, 8, 12, and 24 hours) per steer ($n = 2$) were used. All samples were suspended in the rumen at times appropriate for the desired incubation time interval and removed simultaneously. Upon removal, all samples were hand-washed individually for approximately 20 seconds per bag under a continuous stream of luke-warm tap water. Samples that were not incubated were washed using the same procedure and were used to determine the amount of sample that was washed out.

Washed *in situ* bags were dried for 48 hours at 140°F in a forced-air oven to determine *in situ* dry matter disappearance. Residual corn samples were removed from the bags, composited by time period, ground with a mortar and pestle, and frozen. A subsample was weighed and analyzed for starch disappearance at the Kansas State University Ruminant Nutrition Laboratory using enzymatic hydrolysis. Samples were analyzed in duplicate and if samples differed in total starch between duplicates by 5% or greater they were re-analyzed. Duplicates were averaged.

Fecal starch, feedlot performance, and continuous carcass data were analyzed on a pen mean basis and dry rolled corn particle size data were analyzed on a collection mean basis as a randomized complete block design using PROC MIXED of SAS (version 9.3, SAS Institute, Cary, NC). Treatment was used as a fixed effect and pen as a random ef-

fect. Average daily dry matter intake for each week was evaluated using MIXED model procedures with treatment, week, and treatment \times week included in the model as fixed effects. Quality grade (Low Choice and greater versus Select and lower) and yield grade (yield grade 1, 2, or 3 versus yield grade 4 and 5) data were evaluated as categorical responses using PROC GLIMMIX of SAS and assuming a binomial distribution. Significance was determined at $P \leq 0.05$. Treatment means were separated using orthogonal contrasts if the effect for treatment approached significance. Contrasts of interest were steam-flaked corn versus dry-rolled corn and the linear and quadratic effects of decreasing particle size among the dry-rolled corn treatments.

Results and Discussion

Final body weight and average daily gain were not affected by treatment ($P > 0.05$; Table 1). Dry matter intake was greater and gain:feed was lower ($P < 0.05$) for steers fed dry-rolled corn versus steam-flaked corn. There was a linear decrease ($P < 0.05$) in dry matter intake in the final 5 weeks on feed with decreasing dry-rolled corn particle size (Figure 1). Fecal starch decreased (linear, $P < 0.01$) as dry-rolled corn particle size decreased (Table 2). *In situ* starch disappearance was lower for dry-rolled corn versus steam-flaked corn ($P < 0.05$) and increased linearly ($P < 0.05$) with decreasing particle size at 8 and 24 hours (Figure 2). Reducing dry-rolled corn particle size did not influence growth performance but increased starch digestion and influenced dry matter intake of cattle on finishing diets. No differences ($P > 0.10$) were observed among treatments for any of the carcass traits measured (data not shown). Results indicate improved ruminal starch digestibility, reduced fecal starch concentration, and reduced dry matter intake with decreasing dry-rolled corn particle size in feedlot diets containing 20% wet distillers grains on a dry matter basis.

Implications

These results indicate improved ruminal starch digestibility, reduced fecal starch concentration, and reduced dry matter intake with decreasing dry-rolled corn particle size in feedlot diets containing 20% wet distillers grains on a dry matter basis. A better understanding of dry-rolled corn particle size on the influence of feedlot performance with the addition of various levels of wet distillers grains is needed. Based on these data, feeding finely processed corn in diets containing 20% wet distillers grains appears to be acceptable in binding fines and improving homogeneity of diet. Reduced dry matter intake with decreasing dry-rolled corn particle size towards the end of the finishing period could have potentially been associated with a sub-acute acidotic event, but the reason is not clear.

Table 1. Least squares means illustrating the effect of dry-rolled corn particle size on feedlot performance in yearling steers fed diets containing 20% wet distillers grains (dry matter basis)

Item ²	Treatment ¹				SEM ³	Treatment effect ⁴	Probability>F		
	Coarse dry-rolled corn	Medium dry-rolled corn	Fine dry-rolled corn	Steam-flaked corn			Steam-flaked corn vs dry-rolled corn	Dry-rolled corn	
								Linear	Quadratic
Initial weight, lb	840	840	840	840	20.7	0.76	0.58	0.50	0.49
Day 17 weight, lb ⁶	908	926	922	917	4.4	0.06	0.99	0.08	0.07
Final weight, lb ⁶	1,404	1,411	1,402	1,413	9.9	0.81	0.60	0.87	0.42
Finish period									
Average daily gain, lb	4.37	4.25	4.21	4.32	0.088	0.61			
Dry matter intake, lb	12.31	12.15	12.17	11.50	0.256	0.11	0.02	0.68	0.77
Gain:feed ⁶	0.162	0.159	0.158	0.171	0.0035	0.05	< 0.01	0.43	0.84
Calculated net energy for maintenance ⁷	88.9	88.5	88.0	93.5	1.35	0.03	< 0.01	0.69	0.97
Calculated net energy for gain ⁷	59.3	59.0	58.6	63.4	1.19	0.03	< 0.01	0.69	0.97
Dry matter intake last 5 weeks, lb	27.78	27.56	26.94	24.85	0.476	< 0.01	< 0.01	< 0.01	0.15
Overall									
Average daily gain, lb ⁵	4.34	4.41	4.32	4.41	0.075	0.80	0.58	0.50	0.49
Dry matter intake, lb ⁵	26.06	25.79	25.86	24.56	0.514	0.14	0.02	0.77	0.78
ca Final body weight, lb ⁸	1,400	1,415	1,404	1,408	10.1	0.74	0.088	0.076	0.26
ca Average daily gain, lb ⁸	4.32	4.41	4.34	4.39	0.077	0.79	0.83	0.82	0.29
Gain:feed ⁵	0.168	0.171	0.168	0.180	0.0030	0.03	< 0.01	0.87	0.47
Calculated net energy for maintenance ⁷	90.0	91.0	90.0	94.9	1.23	0.02	< 0.01	0.99	0.55
Calculated net energy for gain ⁷	60.4	61.2	60.3	64.7	1.08	0.02	< 0.01	0.99	0.55

¹ Coarse dry-rolled corn (0.192 in.); medium dry-rolled corn (0.148 in.); fine dry-rolled corn (0.093 in.); steam-flaked corn (27 lb/bu).

² Least squares treatment mean.

³ Standard error of the least squares mean.

⁴ Treatment as a fixed model effect.

⁵ Initial body weight used as a covariate, P<0.10.

⁶ Day 17 body weight used as a covariate, P<0.10.

⁷ Calculated from performance, Mcal/100 lb diet dry matter.

⁸ Carcass adjusted for average dressing percent 66.0%.

Table 2. Least squares means illustrating the effect of dry-rolled corn particle size on fecal starch content in yearling steers fed diets containing 20% wet distillers grains (dry matter basis)

Item ²	Treatment ¹				SEM ³	Probability>F ⁴			
	Coarse dry-rolled corn	Medium dry-rolled corn	Fine dry-rolled corn	Steam-flaked corn		Treatment effect	Steam-flaked corn versus dry-rolled corn	Dry-rolled corn	
							Linear	Quadratic	
Fecal starch	13.92	10.41	7.64	2.12	0.594	< 0.01	< 0.01	0.66	

¹ Coarse dry-rolled corn (0.192 in.); medium dry-rolled corn (0.148 in.); fine dry-rolled corn (0.093 in.); steam-flaked corn (27 lb/bu).

² Percentage of dry matter.

³ Standard error of the least squares mean.

⁴ Treatment effect; steam-flaked vs dry-rolled corn; dry-rolled corn linear; dry-rolled corn quadratic.

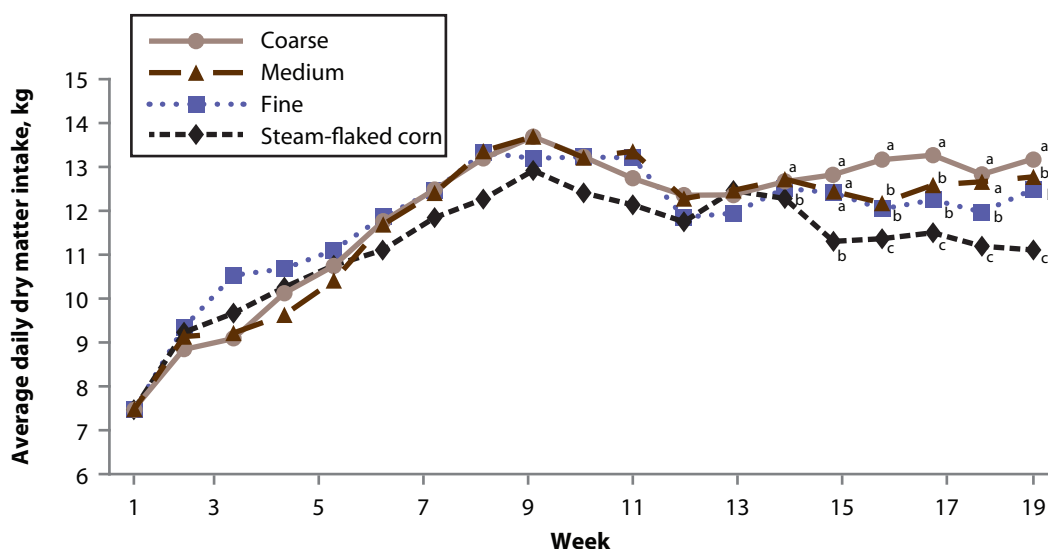


Figure 1. Weekly average daily dry matter intake by treatment for cattle fed coarse dry-rolled corn (0.192 in.); medium dry-rolled corn (0.148 in.); fine dry-rolled corn (0.093 in.); steam-flaked corn (27 lb/bu). Treatment by week interaction was significant ($P < 0.05$). For any given week, means without a common superscript are different ($P < 0.05$). Standard error of the least squares mean = 0.501.

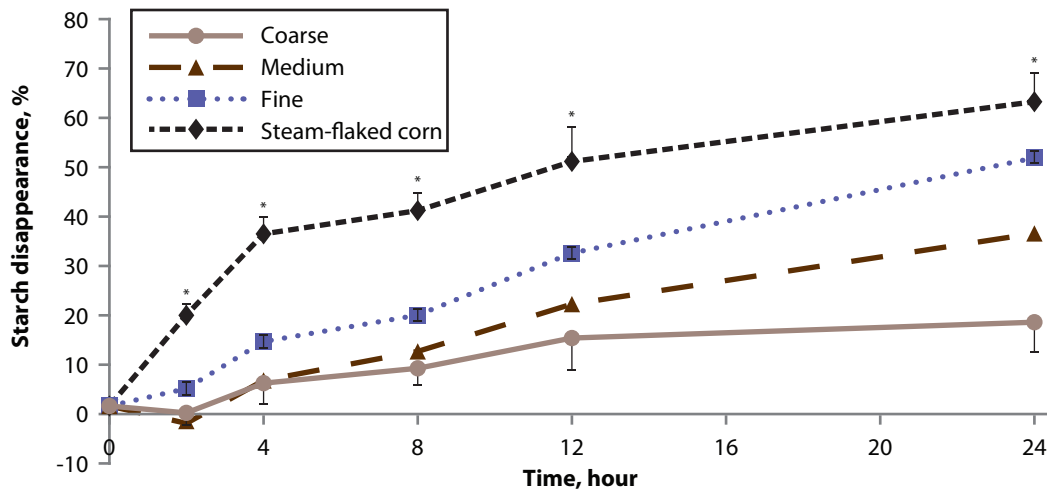


Figure 2. The disappearance of starch from Dacron bags suspended in the rumen for 0, 2, 4, 8, 12, or 24 hours. Treatments were coarse dry-rolled corn (0.192 in.); medium dry-rolled corn (0.148 in.); fine dry-rolled corn (0.093 in.); steam-flaked corn (27 lb/bu). Treatment ($P < 0.01$), time ($P < 0.01$), and the treatment by time interaction ($P < 0.01$) effects for *in situ* starch disappearance were significant. After 24 hours incubation, *in situ* starch disappearance was approximately 18.0, 36.2, 52.0, and 63.1% (Standard error of the least squares mean = 5.44) for the coarse, medium, and fine dry-rolled corn, and steam-flaked corn treatments, respectively (*steam-flaked corn vs. dry-rolled corn, $P < 0.05$; † dry-rolled corn linear, $P < 0.05$).