Corn grain processing and forage inclusion effects on finishing cattle growth performance and feeding behavior

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The objective of this experiment was to determine the effect of corn grain processing (dry-rolling vs. corn) and forage inclusion (5% vs. 15% of diet dry matter) on finishing cattle performance, feeding behavior and carcass characteristics. Our data indicate that feeding whole corn grain vs. dry-rolled corn and increasing forage inclusion in finishing diets increases dry matter intake without influencing average daily gain.

Summary

Seventy steers (776 ± 12.1 lb of body weight) were used to determine the effect of corn grain processing (dry-rolling vs. whole) and forage inclusion (5% vs. 15% inclusion, dry matter basis) on growth performance, feeding behavior and carcass characteristics. Steers were allotted by body weight to one of three pens. Within each pen, steers were assigned randomly to one of four dietary treatments: 1) dry-rolled corn + 5% forage [n = 19], 2) whole corn + 5% forage [n = 15], 3) dry-rolled corn + 15% forage [n = 18] and 4) whole corn + 15% forage [n = 18]. Intake and feeding behavior traits were calculated from data generated using the Insentec feeding system. Steers were slaughtered with an average body weight of 1382 ± 26.7 lb and were slaughtered in two groups at day 142 (n = 40) and day 203 (n = 30) of the finishing period. Final body weight and average daily gain were not influenced ($P \geq 0.12$) by dietary treatment. Dry matter intake was greater ($P \leq 0.004$) in steers fed whole corn grain and in steers fed 15% forage. Hot carcass weight, ribeye area, 12th rib fat and marbling score were not influenced ($P \geq 0.45$) by dietary treatment. Number of visits to the feeder per day was greater ($P = 0.01$) in steers fed 15% forage and number of meals per day was greater ($P = 0.004$) in steers fed dry-rolled corn. Time eating per day was greater ($P \leq 0.04$) in steers fed whole corn grain and in steers fed 15% forage. Time eating per meal was greater ($P = 0.002$) in steers fed whole corn grain. Dry matter intake per meal was greater ($P < 0.001$) in steers fed whole corn and tended to be greater ($P = 0.06$) in steers fed 15% forage. Our data indicate that feeding whole corn grain vs. dry-rolled corn and increasing forage inclusion in finishing diets increases dry matter intake without influencing average daily gain. Forage inclusion level does not seem to influence the effects of corn grain processing on growth performance. Efficiency of nutrient utilization seems to be improved when feeding dry-rolled corn vs. whole corn grain. Therefore, the decision to dry-roll corn for finishing diets is dependent on availability and cost of feed processing equipment for on-site rolling or costs of purchasing dry-rolled corn vs. whole corn grain.

Introduction

Feed costs represent the largest direct cost in beef production. Grain processing and forage inclusion level are two of the major factors influencing production efficiency in finishing operations. For smaller operations, such as farmer feeders or cow/calf producers finishing their own calves, equipment infrastructure for grain processing can dictate what is feasible, and dry-processing may be the best option in most cases.

There are many considerations when making the decision to dry-roll or not. The primary reason for grain processing is to increase the surface area of the grain to allow the microbes in the rumen to have better access to the inside of the kernel, containing starch, which is highly digestible and provides the majority of the energy for typical finishing cattle diets in North America. However, too much highly available starch can be detrimental and result in the microbes in the rumen producing excess acid, which can reduce growth performance because of influences on feed intake and ruminal and liver tissue health. Therefore, it is important to optimize grain processing to maximize digestion without the negative consequences of ruminal acidosis. Additionally, forage inclusion level influences ruminal fermentation and pH because consuming forage results

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in more chewing, rumination and salivation, which helps buffer the pH of the rumen.

Owens et al. (1997) summarized data from several studies that examined effects of grain source and processing method on growth performance of finishing cattle and reported that finishing cattle fed diets containing whole corn grain had improved gain-to-feed ratios compared with those fed dry-rolled corn. However, the results were summarized and calculated across several studies, and typically, the diets containing whole corn grain contained a lower inclusion of forage, which could have increased energy supply since corn has more dietary energy than forage. Therefore, our objective was to determine the effects of corn grain processing (dry-rolled vs. whole) and forage inclusion level (5% vs. 15% of DM) on growth performance and feeding behavior. We hypothesized that corn grain processing would influence growth performance differently depending on forage inclusion level.

Procedures

All procedures with animals were approved by the North Dakota State University (NDSU) Animal Care and Use Committee. Seventy steers (776 ± 12.1 lb of body weight), predominantly of Angus and Simmental breeding, were used in a 2 × 2 factorial arrangement of treatments to determine the effect of corn grain processing (dry-rolling vs. whole) and forage inclusion (5% vs 15% inclusion, dry matter basis) on growth performance, feeding behavior and carcass characteristics. Steers were allotted into three pens (light, medium and heavy pens) and housed at the NDSU Beef Cattle Research Complex. Within each pen, steers were assigned randomly to one of four dietary treatments: 1) dry-rolled corn + 5% forage [n = 19], 2) whole corn + 5% forage [n = 15], 3) dry-rolled corn + 15% forage [n = 18] and 4) whole corn + 15% forage [n = 18]. Diets were offered for ad libitum intake. Steers were adapted to experimental diets by transitioning to the final diet over a 21-day period. Intake and feeding behavior traits were calculated from data generated via the Insentec feeding system. Steers were slaughtered with an average body weight of 1382 ± 26.7 lb and were slaughtered in two groups at day 142 (n = 40) and day 203 (n = 30) of the finishing period. Data were analyzed as a completely randomized block (days to slaughter) design using the mixed procedure of SAS with a 2 × 2 factorial arrangement of treatments. Data were considered significant when $P \leq 0.05$, and a tendency was considered when $0.05 < P \leq 0.10$.

Results and Discussion

Final body weight and average daily gain were not influenced ($P \geq 0.12$) by dietary treatment (Table 3). Dry matter intake was greater ($P \leq 0.004$) in steers fed whole corn grain and in steers fed 15% forage. Hot carcass weight, ribeye area,

Table 1. Diet composition.

	Treatment			
	5% forage		15% forage	
Dietary Component, % of DM	Dry-rolled	Whole	Dry-rolled	Whole
Corn, dry-rolled	77.5	-	62.5	-
Corn, whole	-	77.5	-	62.5
DDGS	10	10	10	10
Corn silage	5	5	15	15
Grass hay	2.5	2.5	7.5	7.5
Fine-ground corn	1.61	1.61	1.61	1.61
Limestone	1.5	1.5	1.5	1.5
Urea	1.0	1.0	1.0	1.0
Salt	0.1	0.1	0.1	0.1
Vitamin premix[1]	0.01	0.01	0.01	0.01
Mineral premix[2]	0.05	0.05	0.05	0.05
Rumensin[3]	0.02	0.02	0.02	0.02

[1]Contained 48,510 kIU/kg vitamin A and 4,630.5 kIU/kg vitamin D.
[2]Contained 3.62% Ca, 2.56% Cu,16% Zn, 6.5% Fe, 4.0% Mn, 1.050 mg/kg I, and 250 mg/kg Co.
[3]Contained 176.4 g monensin/kg premix.

Table 2. Analyzed nutrient concentrations of diets (DM basis).

	Treatment			
	5% forage		15% forage	
Dietary Component, % of DM	Dry-rolled	Whole	Dry-rolled	Whole
Organic matter	95.9	95.9	93.9	93.8
Crude protein	14.5	14.6	14.7	14.9
Neutral detergent fiber	20.0	20.4	27.5	26.5
Acid detergent fiber	4.63	4.70	6.11	7.22
Starch	56.7	58.2	47.0	37.9
Ether extract	3.36	3.36	2.95	2.97
Calcium	0.54	0.52	0.82	0.78
Phosphorus	0.34	0.34	0.33	0.32

12th rib fat and marbling score were not influenced ($P \geq 0.45$) by dietary treatment. Number of visits to the feeder per day was greater ($P = 0.01$) in steers fed 15% forage, and number of meals per day was greater ($P = 0.004$) in steers fed dry-rolled corn (Table 4). Time eating per day was greater ($P \leq 0.04$) in steers fed whole corn grain and in steers fed 15% forage. Time eating per meal was greater ($P = 0.002$) in steers fed whole corn grain. Dry matter intake per meal was greater ($P < 0.001$) in steers fed whole corn and tended to be greater ($P = 0.06$) in steers fed 15% forage.

Research results are inconsistent across studies when examining the effects of including dry-rolled corn vs. whole corn in finishing cattle diets on growth performance. When data were summarized using data from several studies, Owens et al. (1997) reported that cattle fed diets containing whole corn grain had decreased dry matter intake and improved gain-to-feed ratios compared with those fed dry-rolled corn. However, the results were summarized and calculated from several studies, and typically, the diets containing whole corn grain contained a lower inclusion of forage, which could have increased energy supply since corn has more dietary energy than forage. This is in contrast to the observed increase in dry matter intake in steers fed diets containing whole corn grain in the current experiment. Reasons for this discrepancy are not clear, but because digestibility (and thus

Table 3. Effects of grain processing and forage inclusion on growth performance and carcass characteristics in finishing cattle.

	Treatment							
	5% forage		15% forage					
Item	Dry-rolled	Whole	Dry-rolled	Whole	SEM[a]	Processing	Forage	Processing × forage
Initial weight, lb	764	797	767	779	26.2	0.40	0.32	0.52
Final weight, lb	1351	1387	1396	1396	57.7	0.39	0.32	0.52
Average daily gain, lb/d	3.22	3.18	3.37	3.40	0.126	0.95	0.12	0.79
Dry matter intake, lb	24.5	25.7	26.9	28.5	0.51	0.004	<0.001	0.79
Gain:feed	0.131	0.126	0.125	0.119	0.004	0.071	0.13	0.80
Hot carcass weight, lb	864	862	877	869	16.1	0.68	0.47	0.84
Ribeye area, in^2	12.9	13.1	13.1	13.4	0.34	0.54	0.45	0.88
12th rib fat, in	0.685	0.530	0.705	0.646	0.0445	0.54	0.45	0.88
Marbling score[b]	544	522	549	537	25.1	0.47	0.69	0.83

[a]Standard error of the mean (n = 15).
[b]400 to 499 = small, 500 to 599 = modest.

Table 4. Effects of grain processing and forage inclusion on feeding behavior in finishing cattle.

	Treatment					*P*-value		
	5% forage		15% forage					
Item	Dry-rolled	Whole	Dry-rolled	Whole	SEM[a]	Processing	Forage	Processing × forage
Events, per d								
Visits	34.3	36.6	40.8	43.2	2.66	0.35	0.01	0.98
Meals	8.77	7.93	8.93	8.33	0.277	0.007	0.29	0.64
Time eating, min								
Per visit	2.69	2.91	2.76	2.77	0.244	0.63	0.87	0.65
Per meal	10.2	12.6	11.5	13.5	0.708	0.002	0.11	0.77
Per day	89.4	98.9	101.1	111.4	5.14	0.04	0.01	0.93
Eating rate, lb								
Per visit	0.744	0.765	0.727	0.705	0.051	0.99	0.42	0.65
Per meal	2.82	3.29	3.06	3.46	0.118	<0.001	0.06	0.79
Per min	0.294	0.271	0.272	0.260	0.014	0.19	0.22	0.68

[a]Standard error of the mean (n = 15).

dietary) net energy concentration of diets containing whole corn grain is likely decreased, it would be expected that dry matter intake would be greater in cattle fed diets containing whole corn grain because dry matter intake typically increases when less energy-dense finishing diets are fed (Krehbiel et al., 2006). Similarly, we also observed an increase dry matter intake in steers fed diets containing 15% forage, likely because of the effects that forage inclusion has on digestibility and energy density of the diet. The lack of an interaction between corn processing and forage inclusion suggests that the effects of corn processing on growth performance measures are not influenced by forage inclusion level. Overall, the observed decrease in feed intake and gain-to-feed ratio suggests that dry-roll processing improves the efficiency of nutrient utilization in finishing cattle, at least with forage inclusion levels between 5% and 15% of the diet dry matter.

The observed increases in time spent eating per day in steers fed whole corn grain and in steers fed 15% is consistent with past research that has shown that feeding diets that are less digestible results in increased time eating per day (Carvalho et al., 2020; Carvalho and Felix, 2021). Consistent with these findings, we also observed that steers fed whole corn grain spent more time eating per meal and consumed more feed per meal than steers fed dry-rolled corn. This could be because whole corn grain requires greater mechanical breakdown of the corn for efficient utilization, resulting in slower consumption and more chewing and rumination.

In conclusion, forage inclusion level did not influence the effects of corn grain processing on growth performance. Efficiency of nutrient utilization tended to be improved when feeding dry-rolled corn vs. whole corn grain. The decision to dry-roll corn for finishing diets is dependent on availability and cost of feed processing equipment for on-site rolling or costs of purchasing dry-rolled corn vs. whole corn grain.

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