Utilization of Distillers Grains form the Fermentation of Sorghum or Corn in Diets for Finishing Beef and Lactating Dairy Cattle

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ABSTRACT: Beef finishing and dairy lactation experiments were conducted to evaluate the nutritional value of distillers grains (DG) from sorghum or corn fermentation, in both wet (35.4% DM) and dry (92.2% DM) form (dairy trial only). In the finishing experiment, 60 yearling steers were used in a completely randomized design with three diets that were fed for 127 d: 1) control diet with 86% (DM basis) dry-rolled corn and no DG; 2) 30% of ration DM as wet corn DG in place of dry-rolled corn; and 3) 30% of ration DM as wet sorghum DG in place of dry-rolled corn. All diets contained a minimum of 6.8% degradable intake protein and 13.0% CP. Steers fed DG had 10% greater ADG (< 0.01) and 8% greater efficiency of gain ($P < 0.01$) than steers fed the control diet. Wet corn and sorghum DG resulted in similar ADG and efficiency of gain. Hot carcass weights, fat thickness, and yield grades were greater for steers fed DG than for controls ($P < 0.07$). Improvements in ADG and feed efficiency observed when DG replaced dry-rolled corn indicated that the NE_g content of wet DG is approximately 29% greater than that of dry-rolled corn. In the dairy lactation experiment, 16 lactating Holstein cows (eight multiparous, including four fistulated) were used in a replicated 4×4 Latin square design with 4-wk periods. Corn and sorghum DG were fed at 15% of the ration DM in either wet or dry form. Diets were fed as total mixed rations that contained 50% of a 1:1 mixture of alfalfa and corn silages, 24.3% ground corn, and 9.1% soybean meal (DM basis). There was no effect of source or form of DG on DMI, ruminal pH and VFA, or in situ digestion kinetics of NDF from DG. Efficiency of milk production was unaffected by diet. Corn and sorghum DG resulted in relatively similar performance when fed to beef or dairy cattle in this study.

Key Words: Beef Cattle, Dairy Cattle, Distillers Grains, Maize, Sorghum

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Introduction

Distillers grains (**DG**) from fermentation of sorghum and corn grains are a common component of diets fed to beef and dairy cattle, but no direct comparison of these two DG sources has ever been conducted. Replacement of 40% of dry-rolled corn with wet corn DG increased ADG and feed efficiency relative to steers fed dry-rolled corn only (Larson et al., 1993; Ham et al., 1994). These experiments suggested that wet corn DG contains approximately 40% more energy for gain than dry-rolled corn. The higher energy content could be due to higher lipid content in DG compared with corn and a reduction in subacute ruminal acidosis.

Lodge et al. (1997) evaluated wet DG produced at a commercial ethanol plant from a blend of 80% corn and 20% sorghum DG. Similar ADG and feed efficiency were observed when finishing beef steers were fed diets of dry-rolled corn or when 40% of the corn was replaced by wet DG. These data suggested that the energy content of 80% sorghum DG is similar to that of dry-rolled corn, and when compared with the results of Ham et al. (1994), indicated that sorghum DG have a lower energy content than corn DG.

No analogous research concerning sorghum and corn DG has been conducted with lactating dairy cattle. Additionally, dairy cattle routinely are fed DG in either a wet or dry form based primarily on herd size and feeding system. The lamb NDF digestibility data of Lodge et al. (1997) indicated an advantage for sorghum over corn DG when fed dry, but not when fed as wet DG. Whether this difference in NDF digestibility exists for dairy cattle has not been evaluated.

The objectives of these experiments were 1) to determine the energy content of wet DG produced from the

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Table 1. Chemical composition of distillers grains used in beef and dairy experiments

Item	Corn distillers grains Dry	Corn distillers grains Wet	Sorghum distillers grains Dry	Sorghum distillers grains Wet
DM, %	93.0	35.5	91.4	35.3
	(% of DM)			
CP	28.9	30.5	32.9	31.2
ADF	25.5	25.3	28.4	28.5
NDF	42.3	42.6	45.8	41.3
Ether extract	14.0	14.5	13.0	13.3
Nonfiber carbohydrate[a]	9.8	7.4	3.3	9.2

[a]Calculated as 100 − ash − ether extract − CP − NDF.

Table 2. Ingredient composition of experimental diets fed to finishing steers (% of DM)

Item	Control	Distillers grains Corn	Distillers grains Sorghum
Ingredient			
Dry-rolled corn	84	54	54
Corn distillers grains	—	30	—
Sorghum distillers grains	—	—	30
Alfalfa hay	7.5	7.5	7.5
Molasses	3.5	3.5	3.5
Supplement[a]	5.0	5.0	5.0
Chemical composition			
CP	13.0	16.1	17.2
DIP[b]	6.9	8.0	8.6
Ether extract	5.8	8.2	7.9
Ca	0.70	0.70	0.72
P	0.32	0.44	0.46
K	0.60	0.67	0.70
S	0.16	0.22	0.22

[a]Supplement contained 22.3% Ca, 1.36% Mg, 5.2% K, 5.7% Na, 1,441 ppm of Cu, 7,686 ppm of Mn, 1,152 ppm of Zn, 46,000 IU/kg of vitamin A, 8 IU/kg of vitamin D, and 10 IU/kg of vitamin E.

[b]Degradable intake protein. The undegradable intake protein content was estimated using the in situ techniques outlined by Wilkerson et al. (1995).

fermentation of 100% sorghum or 100% corn grains in finishing diets fed to yearling beef steers and 2) to evaluate the effect of the same corn and sorghum DG, in both wet and dry forms, on NDF digestion and short-term lactational performance in dairy cattle.

Materials and Methods

Production and Supply of Distillers Grains

Distillers grains were produced at a commercial dry milling plant (Chief Ethanol Fuels, Hastings, NE) from one fermentation batch for each source of grain. The chemical composition of the DG is given in Table 1. Unlike in previous experiments, the DG were produced from fermentation of either 100% corn or 100% sorghum. Enough of each of the four DG products (corn and sorghum, wet and dry) was prepared at the commercial plant for both the beef and dairy experiments. The wet DG was stored in plastic silage bags and the dry DG were stored in metal bins prior to initiation of the cattle experiments. As the silage bags and bins were filled, representative DG samples were collected, dried at 60°C in a forced-air oven, ground through a Wiley mill (1-mm screen; Arthur H. Thomas Co., Philadelphia, PA), and analyzed for DM (AOAC, 1990), CP and ether extract (AOAC, 1990), ADF, and NDF (Van Soest et al., 1991).

Beef Steer Finishing Experiment

Sixty Red Angus yearling steers (360 ± 5 kg) were used in a completely randomized design experiment to compare wet corn and sorghum DG in corn-based finishing diets. Steers were assigned randomly to one of three finishing diets (Table 2). All diets were formulated to contain a minimum of 13% CP, 6.8% degradable intake protein, 0.7% Ca, 0.3% P, 0.6% K, 28 g/t Rumensin (Elanco Animal Health, Greenfield, IN), and 10 g/t Tylan (Elanco Animal Health). Steers were fed individually using Calan electronic gates (American Calan, Northwood, NH). Steers were adapted to their finishing diet by gradually increasing the amount of feed offered until steers reached ad libitum consumption. Steers were offered their respective finishing diet on d 1 at 5.5 kg/steer (DM basis). Feed offered was then increased by 0.23 kg/d (DM basis) until steers were at ad libitum consumption (approximately 21 d).

Steers were weighed initially on three consecutive days after being limit-fed a 50% alfalfa:50% dry-rolled corn diet (DM basis) for 5 d to minimize gut fill differences. Steers were implanted with Revalor-S (Intervet, Somerville, NJ) on d 1 and fed experimental diets for a total of 127 d. Hot carcass weights were collected on all steers at the time of slaughter, whereas other carcass characteristics were collected by trained personnel following a 24-h chill. Final weights were calculated using hot carcass weights adjusted to a common dressing percentage of 63%. Dietary NE_g values were calculated, based on steer performance, using the iterative procedure described by Zinn (1987).

Dairy Metabolism and Lactation Experiment

Cows and Treatments. Twelve Holstein cows (four primiparous), averaging 98 ± 9 d in milk, were assigned randomly within parity to one of four diets in replicated 4 × 4 Latin squares with 4-wk periods to measure DMI, milk production, and milk composition. Initial DMI and 4% fat-corrected milk production for the primiparous cows were 22.3 and 28.2 kg/d, respectively, and 24.1 and 29.5 kg/d, respectively, for the multiparous cows. Four ruminally fistulated, multiparous cows (139 ± 6 d in milk) were assigned randomly to the same diets to measure ruminal and total tract NDF digestion, ruminal pH, and VFA concentrations. The fistulated cows averaged 24.0 kg/d DMI and 28.9 kg/d fat-corrected

Table 3. Ingredient and chemical composition of experimental diets fed to lactating dairy cows

	Corn distillers grains		Sorghum distillers grains	
	Dry	Wet	Dry	Wet
Ingredient	(% of DM)			
Alfalfa silage[a]	25.0	25.0	25.0	25.0
Corn silage[b]	25.0	25.0	25.0	25.0
Dry corn distillers grains	15.0	—	—	—
Wet corn distillers grains	—	15.0	—	—
Dry sorghum distillers grains	—	—	15.0	—
Wet sorghum distillers grains	—	—	—	15.0
Ground corn	24.3	24.3	24.3	24.3
Soybean meal (46.5% CP)	9.1	9.1	9.1	9.1
Mineral and vitamin mixture[c]	1.6	1.6	1.6	1.6
Composition				
DM, %	52.6	49.1	53.9	47.2
CP	18.2	18.8	18.4	18.7
UIP[d]	5.8	5.9	5.2	6.0
ADF	22.5	23.1	22.4	22.9
NDF	32.7	32.6	32.4	33.5
Ether extract	4.3	4.4	4.1	4.0

[a]Composition of alfalfa silage was (% of DM): 19.4% CP, 35.0% ADF, and 43.8% NDF.
[b]Composition of corn silage was (% of DM): 8.9% CP, 24.2% ADF, and 41.4% NDF.
[c]Mixture contained 15.2%Ca, 7.2%P, 4.1% Mg, 4% Na, 3,000 ppm of Zn, 1,750 ppm of Mn, 400 ppm of Cu, 200,000 IU/kg of vitamin A, 36,000 IU/kg of vitamin D_3, and 600 IU/kg of vitamin E.
[d]Undegradable intake protein measured using in situ method of Wilkerson et al. (1995).

milk at initiation of the experiment. The cows used in this experiment were fistulated and housed under conditions described in animal use protocols approved by the Institutional Animal Care and Use Committee at the University of Nebraska.

Dietary treatments were 1) dry corn DG, 2) dry sorghum DG, 3) wet corn DG, and 4) wet sorghum DG. All diets contained 15% of the DG product and 50% of a 1:1 mixture of alfalfa and corn silages, 24.3% ground corn, 9.1% soybean meal, and 1.6% mineral and vitamin supplement (DM basis; Table 3). Diets were formulated to be isonitrogenous (18.5% CP), to meet the undegradable intake protein requirement for cows producing 35 kg/d milk (NRC, 1989), and were fed as total mixed rations twice daily in amounts to ensure 10% orts. Cows were housed in a tie-stall barn equipped with individual feed boxes and were removed twice daily for milking, exercise, and estrus detection for a total of 5 to 6 h daily.

Sample Collection and Analysis. Samples of silages and total mixed rations were composited weekly for analyses. Weekly composite samples were oven-dried (60°C), ground through a Wiley mill (1-mm screen), and analyzed for CP (AOAC, 1990), ADF, and NDF (Van Soest et al., 1991). The undegradable intake protein content of each diet was measured using the in situ technique of Wilkerson et al. (1995).

Daily milk production was recorded electronically for all cows. Composite a.m. and p.m. milk samples were collected twice during wk 4 of each period and analyzed for percentage of fat, protein, and lactose (Milko-Scan Fossomatic; Foss Food Technology, Eden Prairie, MN). Calculation of milk composition was weighted according to a.m. and p.m. milk production. Body weight was measured weekly immediately after the a.m. milking.

Samples of ruminal fluid were collected directly beneath the ruminal digesta mat during wk 4 of each period from ruminally fistulated cows at 4-h intervals for 24 h. The pH of ruminal fluid was measured immediately using a portable pH meter, and concentrations of VFA were determined by GLC (Erwin et al., 1961) with run conditions described by Ham et al. (1994).

Fractional rate of NDF digestion of each DG product was measured using the in situ bag technique in which Dacron bags containing 5 g of substrate were incubated in duplicate within the rumen of each cow for 0, 6, 12, 24, 48, or 72 h. Dacron bags (Ankom, Fairport, NY) were 10 × 20 cm with a mean pore size of 53 μm. Due to the small particle size of the DG, samples were not ground prior to ruminal incubation. After removal from the rumen and rinsing (Wilkerson et al., 1995), all bags were dried at 60°C and weighed. Contents were analyzed for ash-free NDF (Van Soest et al., 1991), and values within incubation time were pooled. The model for ruminal NDF digestion was described by Mertens and Loften (1980). The kinetics of NDF digestion and apparent extent of ruminal NDF disappearance were calculated as described by Grant (1994). Briefly, the kinetic parameters were estimated using nonlinear regression. The Marquardt option of nonlinear regression in SAS (1996) was chosen.

Total tract ADF and NDF digestibilities were measured during wk 4 of each period using only the ruminally fistulated cows. Feed samples and rectal grab samples of feces were taken daily at the a.m. feeding for indirect estimation of digestibility using the sampling protocol of Nakamura and Owen (1989). All feed and fecal samples were frozen and later composited prior to chemical analyses. Total tract ADF and NDF digestibilities were determined using the acid-insoluble ash ratio technique (Van Soest et al., 1991).

Statistical Analyses

For the beef finishing experiment, data for animal performance and carcass characteristics were analyzed by the GLM procedure of SAS (1996) for a completely randomized experiment, with animal as the experimental unit. Orthogonal contrasts were used to compare the control diet vs the average of treatments containing wet corn and sorghum DG and wet corn DG vs wet sorghum DG. The percentage of carcasses grading USDA Choice were analyzed by the FREQ procedure of SAS (1996).

For the dairy experiment, data for intake and milk production were analyzed using the model for a replicated Latin square design by the GLM procedure of

Table 4. Effects of corn and sorghum distillers grains on performance and calculated dietary NE_g values in dry-rolled corn-based diets fed to finishing yearling steers

		Distillers grain type			Probabilities[a]	
Item	Control	Corn	Sorghum	SE	Control vs distillers	Corn vs sorghum
Number of steers	19	20	19			
Performance						
Initial weight, kg	359	358	359	5		
Final weight, kg[b]	570	587	598	8	0.03	0.37
DMI, kg/d	10.7	10.4	11.1	0.2	0.71	0.02
Daily gain, kg	1.65	1.80	1.87	0.04	<0.01	0.19
Gain/feed, kg/kg	0.156	0.173	0.168	0.110	<0.01	0.25
Calculated NE_g values, Mcal/kg						
Diet	1.28	1.43	1.39	0.02	<0.01	0.15
Wet distillers grains	—	2.00	1.87			

[a]Control vs distillers = Control vs the average of wet corn and sorghum distillers grains; Corn vs sorghum = corn vs sorghum distillers grains.
[b]Determined as hot carcass weight/0.63.

SAS (SAS Inst. Inc.) with a factorial arrangement of treatments. Model included factors for square, cow within square, period within square, treatment, treatment × square, and residual error. Measurements from ruminally fistulated cows were analyzed using a model for an unreplicated Latin square design by the GLM procedure of SAS (SAS Inst. Inc.) with factors of cow, period, and treatment. Orthogonal comparisons were 1) corn vs sorghum DG, 2) wet vs dry DG, and 3) interaction of source and DM content of DG. Significance was declared at $P < 0.10$.

Results and Discussion

Chemical Composition of Distillers Grains

Table 1 contains the chemical composition data for the DG products used in both the beef and the dairy experiments. The wet and dry DG averaged 35.4 and 92.2% DM, respectively. All four DG were similar in content of CP (average 30.9%), ADF (average 26.9%), and NDF (43.0%). The sorghum DG were slightly higher in ADF than the corn DG. The wet DG were removed from the silage bags during both experiments, so they were in excellent condition with no visible signs of heating or molding.

Beef Finishing Experiment

Results of performance data are presented in Table 4. Averaged across source of wet DG, DMI of steers fed DG was similar to that of steers fed the control diet. Within DG diets, DMI of steers fed wet sorghum DG was higher ($P < 0.02$) than that of steers fed wet corn DG. Similar DMI between the corn-based control diet and the diets containing wet DG are in agreement with previous reports in which the inclusion level of wet DG was between 25 and 50% (Firkins et al., 1985; Ham et al., 1994).

Compared with steers fed the control diet, steers fed diets containing wet DG gained 10.1% faster ($P < 0.01$) and were 8.5% more efficient ($P < 0.01$). Steers fed wet sorghum DG did not gain more ($P = 0.19$) but also were not ($P = 0.25$) less efficient than those fed wet corn DG. Numerical differences in daily gain and efficiency of gain were similar to those previously reported in the literature. Firkins et al. (1985) reported a linear improvement in daily gain and efficiency of gain when wet DG were fed at up to 50% of the dietary DM. Compared with steers fed a 79% dry-rolled corn diet, yearling steers were 5, 10, and 20% more efficient and steer calves 2, 6, and 14% more efficient when fed 5.2, 12.6, or 40% (DM basis) wet DG, respectively (Larson et al., 1993).

Based on performance, the calculated dietary NE_g value for diets containing wet corn and sorghum DG was, on average, 10.2 % greater than that of the dry-rolled corn control diet. The calculated dietary NE_g values for the wet corn and sorghum DG diets were 11.7 and 8.6% greater, respectively, than that of the dry-rolled corn diet. The dietary NE_g value of the wet corn DG diet was numerically greater ($P = 0.15$) than the dietary NE_g value for the wet sorghum DG diet. Because wet DG comprised 30% of the dietary DM, calculated NE_g values for wet corn and sorghum DG were 33.3 and 24.7% greater than for dry-rolled corn. Based on the data from this experiment, the calculated NE_g values for wet corn and sorghum DG were 2.00 and 1.87 Mcal/kg, respectively. Net energy values greater than those for dry-rolled corn have been reported previously for wet corn DG (Larson et al., 1993; Ham et al., 1994).

Comparisons of wet DG produced exclusively from corn or sorghum are limited. In a lamb metabolism experiment, Lodge et al. (1997) reported lower OM and lower true and apparent nitrogen digestibility for wet sorghum DG compared with wet corn DG. The lamb metabolism experiment of Lodge et al. (1997) supported our findings that DG produced from 100% sorghum may have slightly less energy than DG produced from 100% corn grain.

The ether extract content of the corn (14.5%) and sorghum (13.3%) DG in this experiment was similar to

Table 5. Effects of wet corn and sorghum distillers grains on carcass characteristics in finishing yearling steers

		Distillers grain type			Probabilities[a]	
Item	Control	Corn	Sorghum	SE	Control vs distillers	Corn vs sorghum
Hot carcass weight, kg	359	370	376	5.2	0.03	0.37
Dressing percentage	64.8	64.9	65.4	0.39	0.50	0.42
Longissimus muscle area, cm^2	32.5	32.0	32.5	0.8	0.82	0.63
Fat thickness, cm	1.12	1.29	1.45	0.05	<0.01	0.08
Marbling score[b]	5.58	5.44	5.41	0.14	0.37	0.88
Yield grade	2.32	2.63	2.56	0.12	0.07	0.66
USDA Choice, %[c]	95	70	74			

[a]Control vs distillers = Control vs the average of sorghum and corn distillers grains; Corn vs sorghum = corn vs sorghum distillers grains.
[b]5 = small 0; 5.5 = small 50, etc.
[c]Chi-square statistic ($P = 0.13$).

those values reported in other experiments (Larson et al., 1993; Ham et al., 1994; Lodge et al., 1997). Lipid contains three times more energy than corn grain (Zinn, 1988, 1989). The lipid content of wet corn and sorghum DG used in the present experiment accounts for 4.7 and 4.2% (out of 11.7% and 8.6%) of the improvement in the NE_g content of the diets compared with corn. On average, 42% of the improvement in the calculated dietary NE_g values can be attributed to the added lipid when dry-rolled corn is replaced with wet corn or sorghum DG, whereas 58% of this improvement can be attributed to factors other than the energy contribution from lipid. These factors could be additions of yeast and yeast by-products, added AA and metabolizable protein, added moisture, cofactors, differences in nonfiber carbohydrate fraction (Larson et al., 1993), or a reduction in subacute acidosis (Firkins et al., 1985; Ham et al., 1994).

Results of carcass data are presented in Table 5. Hot carcass weight was heavier ($P < 0.05$) for steers fed wet corn or sorghum DG than for those fed the control diet. Hot carcass weight was similar between steers fed the wet corn or sorghum DG. Fat thickness at the 12th rib ($P < 0.01$) and yield grade ($P = 0.07$) were higher for steers fed wet corn or sorghum DG than for those fed the control diet. Additionally, steers fed wet sorghum DG tended to have ($P < 0.10$) 12th rib fat than those fed wet corn DG. Dressing percentage, longissimus muscle area, marbling score, and the percentage of carcasses grading USDA Choice were similar among treatments. The effects observed on carcass characteristics when wet DG replaced dry-rolled corn are similar to those reported in previous experiments (Larson et al., 1993; Ham et al., 1994; Lodge et al., 1997). Considering the enhanced performance of steers fed wet DG, these changes in carcass characteristics are most likely due to feeding the steers a similar number of days rather than to harvesting the steers at a similar body composition.

Dairy Metabolism and Lactation Experiment

There were no significant effects of treatment on any measure of lactational performance or ruminal digestion ($P > 0.10$). Additionally, there was no effect of square on lactational performance. Despite the lack of significance for the interaction term, means for individual treatment combinations are provided for purposes of discussion.

Chemical composition of diets is presented in Table 3. The DG were added at 15% of the ration DM because a previous review of research with DG in dairy rations indicated that this amount may be nearly optimal for lactation diets based on DMI and milk production response (Chase, 1991). This amount of DG resulted in approximately 21.3 percentage units of dietary NDF from forage, or about 65% of total NDF from forage, which has resulted in increased 4% fat-corrected milk production and DMI when compared with higher forage NDF as a percentage of dietary DM (Grant, 1997).

Table 6 summarizes the effect of DG on DMI and efficiency of milk production. Dry matter intake averaged 25.4 kg/d, or 4.0% of BW for cows on all diets. Neither BW nor change in BW per 4-wk period was affected by diet. Numerically, 4% fat-corrected milk production was approximately 6% lower ($P = 0.15$) for the sorghum DG diets. Efficiency of 4% fat-corrected milk production was similar for cows on all diets and averaged 1.28. Milk fat production was unaffected by diet and reflected the high ruminal pH observed for cows consuming all diets (Table 6).

Nearly all previous research with lactating dairy cows has evaluated replacement of dietary corn or soybean meal with DG, rather than comparing source or form of DG. Early research with dry DG (source not specified) indicated that DG inclusion in the ration in place of corn grain or soybean meal often increased milk fat production (summarized by Chase, 1991). More recently, Owen and Larson (1991) compared dry corn DG with solvent-extracted soybean meal in diets for early-lactation dairy cows that contained 50% of an alfalfa and corn silage mixture. In this experiment, there were no differences in DMI or milk production between the two sources of protein. In our study, all diets contained soybean meal plus DG and supplied adequate metabolizable protein for cows in early lactation according to the Cornell Net Carbohydrate and Protein Model (1994).

Table 6. Performance responses to corn and sorghum distillers grains fed to lactating dairy cows

	Corn distillers grains		Sorghum distillers grains		
Item	Dry	Wet	Dry	Wet	SE
DMI					
kg/d	24.8	25.9	25.9	25.1	1.0
% of BW	3.9	4.0	4.1	4.0	0.2
BW, kg	640	646	641	638	16
BW change per period, kg	10.2	11.2	11.3	15.1	5.1
4% FCM, kg/d[a]	33.3	33.0	31.9	31.3	1.8
FCM/DMI, kg/kg	1.3	1.3	1.3	1.2	0.1
Milk fat					
%	3.7	3.6	3.5	3.5	0.1
kg/d	1.3	1.2	1.2	1.1	0.1
Milk crude protein					
%	3.4	3.3	3.2	3.2	0.1
kg/d	1.2	1.1	1.1	1.0	0.1
Milk lactose					
%	4.7	4.6	4.7	4.8	0.1
kg/d	1.6	1.6	1.7	1.6	0.1

[a]Fat-corrected milk.

Table 7. Effect of corn and sorghum distillers grains on ruminal pH and volatile fatty acid concentrations

	Corn distillers grain		Sorghum distillers grains		
Item	Dry	Wet	Dry	Wet	SE
Rumen pH	6.30	6.50	6.55	6.45	0.11
Total VFA, m*M*	96.1	98.7	96.9	96.5	0.9
Acetate (A)	53.9	54.0	54.4	54.7	0.5
Propionate (P)	24.9	24.4	25.2	25.1	0.3
Butyrate	16.3	16.4	15.5	15.4	0.4
Isobutyrate	1.5	1.4	1.2	1.2	0.1
Valerate	1.7	2.0	2.0	1.9	0.1
Isovalerate	1.7	1.8	1.6	1.7	0.1
A:P ratio	2.20	2.23	2.18	2.15	0.04

Table 8. Digestibility of corn and sorghum distillers grains and total tract fiber digestion

	Corn distillers grains		Sorghum distillers grains		
Item	Dry	Wet	Dry	Wet	SE
In situ NDF digestion of distillers grains					
Lag, h	0.6	0	0	0	
Rate, h^{-1}	0.059	0.041	0.042	0.062	
Extent, %	87.8	86.4	85.1	81.5	
r^2	0.96	0.93	0.93	0.99	
Apparent extent of NDF disappearance[a]	46.1	39.0	38.9	45.2	
Total tract digestion, %					
ADF	62.5	59.7	58.9	57.7	5.7
NDF	64.7	59.2	66.3	62.6	6.9

[a]Calculated using the following equation assuming a fractional passage rate of distillers grains from the rumen of 0.050 h^{-1}: $e^{-kpL} \times [k_d/(k_d + k_p)] \times PED$, where k_p = fractional passage rate of distillers grain particles from the rumen, k_d = fractional rate of ruminal NDF digestion, and PED = potential extent of ruminal NDF digestion.

Shelford and Tait (1986) specifically compared rye and corn DG (dry form) as components of lactation diets that contained 50% alfalfa and 15% DG. These researchers observed no effect of diet on DMI, milk production or composition, or apparent total tract DM digestibility. In our experiment, ruminal pH and acetate:propionate ratio indicated that DG from corn or sorghum, whether wet or dry, resulted in ruminal conditions that were optimal for cell wall fermentation (Table 7). All diets resulted in an acetate:propionate ratio greater than 2.0; ratios below 2.0 have been associated with milk fat depression (Van Soest, 1994). Similarly, the ruminal NDF digestion rate and extent of DG (Table 8) were high, reflecting the high fibrolytic activity associated with ruminal pH greater than 6.2 (Grant, 1994). The fractional rate, lag, and potential extent of NDF digestion observed for corn and sorghum DG were within the range observed previously for other nonforage sources of fiber (Bhatti and Firkins, 1995). Apparent extent of ruminal NDF disappearance from DG (assuming a fractional passage rate from the rumen of 0.050 h^{-1}) ranged between 39 and 46%, with no difference among treatments. Total tract ADF and NDF digestibilities were unaffected by diet and values were typical of a highly digestible lactation diet containing fibrous by-product feeds such as DG (Shelford and Tait, 1986).

In summary, the dairy experiment demonstrated that short-term lactational performance of early lactation dairy cows was similar for corn and sorghum DG, whether wet or dry. Additionally, supplementing the ration with DG from either source at 15% of the DM had no deleterious effects on ruminal pH, NDF fermentation, or total tract NDF digestibility. A longer-term lactation study would clarify the biological significance of the trend observed in 4% fat-corrected milk production.

Implications

Establishing the effect of source of grain on the feeding value of distillers grains in the wet or dry form will allow more accurate economic values to be placed on distillers grains from corn or sorghum when formulating rations for beef or dairy cattle. The distillers grains from either grain source resulted in similar efficiency of production for beef and dairy cattle. Future research is needed to determine whether complementary effects exist when corn and sorghum distillers grains are combined in various ratios, and to determine what the effects of source and form of distillers grains would be on DMI, milk production, and body condition when fed to dairy cattle for a complete lactation.

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