Effects of Supplying Increasing Levels of Distillers Dried Grain with Solubles in Growing Diets on Intake, Digestion and Ruminal Fermentation

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Abstract
Five ruminally- and duodenally-cannulated steers (1,100 ± 11 lbs. of initial body weight [BW]) were used in a 5 x 5 Latin square to evaluate effects of increasing levels of dried corn distillers grains with solubles (DDGS) in growing diets (60 percent concentrate) on organic matter (OM) intake, site of digestion, ruminal fermentation and microbial efficiency. Diets contained 30 percent grass hay, 6 percent concentrated separator byproduct, 4 percent supplement and 60 percent dry-rolled corn, sunflower meal and/or DDGS (dry matter [DM] basis). Treatments consisted of increasing DDGS at 0 percent, 15 percent, 30 percent, 45 percent or 60 percent of dietary DM, replacing a combination of dry-rolled corn and sunflower meal. Diets were balanced for growing steers gaining 2.68 lbs. per day (lbs./d) and included 0.25 percent (DM basis) chromic oxide as a digesta-flow marker. Steers were fed diets in the form of a totally-mixed ration (TMR). Diets were offered to ensure ad libitum intakes and 10 percent feed refusal daily. Steers were adapted to diets for 14 days, followed by a seven-day collection period. Intake of OM responded quadratically ($P = 0.004$), with greatest intakes at 15 percent DDGS and lowest at 60 percent DDGS. No differences ($P > 0.13$) were observed in crude protein (CP) intake. Apparent and true ruminal OM digestion decreased (linear; $P \leq 0.009$) with increasing DDGS inclusion. Total tract CP digestion increased (linear; $P < 0.001$) with increasing DDGS; however, total tract OM digestion was not different ($P = 0.74$). Rumen microbial efficiency was not affected ($P = 0.22$) by treatment. Increasing dietary inclusion of DDGS increased (linear; $P = 0.004$) ruminal pH, while ammonia concentration remained unchanged ($P = 0.42$). Ruminal acetate proportions decreased ($P < 0.001$) with increasing DDGS, while propionate and butyrate were similar ($P \geq 0.19$). Replacing dry-rolled corn with moderate to high levels of DDGS in growing diets resulted in no adverse effects on digestion or ruminal fermentation although OM intake was reduced at 60 percent DDGS inclusion.

Introduction
Rising costs of corn are partially due to an increase in ethanol production. Increased production of ethanol has led to an increase in the amount of available byproducts, such as dried corn distillers grain with solubles (DDGS). For every bushel of corn, approximately 2.7 gallons of ethanol, 18 pounds of DDGS and 18 pounds of carbon dioxide are produced (Lardy, 2003).

Dried distillers grains with solubles are a common component in beef cattle diets because of their availability and nutrient profile. Dried distillers grains plus solubles contain approximately 30 percent CP, 11 percent ether extract (EE), 52 percent undegradable intake protein (UIP) and 46 percent neutral detergent fiber (NDF). Because most of the starch has been removed and DDGS has relatively high NDF levels, DDGS are a source of readily digestible, nonforage fiber (Ham et al., 1994). When DDGS are fed at levels of 6 percent to 15 percent of dietary DM, their primary purpose is to serve as a protein source; however, when fed at higher levels, DDGS become a source of energy replacing corn (Klopfenstein, 2001). Vander Pol et al. (2006) reported the energy value of corn wet distillers grains with solubles to be greater than 100 percent of the value of dry-rolled corn, regardless of inclusion rate.

Increased average daily gain (ADG) and gain-to-feed ratio (G:F) have been demonstrated with 40 percent DDGS inclusion in corn-based finishing diets (Ham et al., 1994). When fed at 20

percent of dietary DM (corn-based diets), DDGS had no effect on nutrient digestion or ruminal fermentation characteristics. Therefore, DDGS are attractive for growing and finishing cattle diets (Larson et al., 1993).

No research is available on including 60 percent DDGS (DM basis) in diets for growing steers. Therefore, our objective was to determine effects of increasing levels of DDGS in diets containing 60 percent concentrate and 40 percent roughage offered to growing steers on DMI, rate and site of digestion, ruminal fermentation, duodenal protein flow and microbial efficiency.

Materials and Methods

Five ruminally- and duodenally-cannulated steers (1,100 ± 11 lbs. initial BW) were used in a 5 x 5 Latin square. Steers were weighed at the initiation of the experiment and housed in a climate-controlled room in individual pens (9.8 feet by 12.1 feet) during each 14-day adaptation period and stalled in individual metabolism crates (3.3 feet by 7.2 feet) during each seven-day collection period. Steers were offered ad libitum access to diets (10 percent above previous day's intake) and water. Hay was chopped through a 4-inch screen. The diet was composed of dry-rolled corn and/or DDGS, grass hay, concentrated separator byproduct, sunflower meal, urea and supplement (Table 1). Diets also included 0.25 percent (DM basis) chromic oxide added as a digesta marker. Treatments consisted of five levels of DDGS (0 percent, 15 percent, 30 percent, 45 percent or 60 percent of dietary DM), replacing dry-rolled corn and sunflower meal. Diets were balanced to meet or exceed all National Research Council (NRC, 1996) recommendations. Feed refusals were collected for determination of DMI. Total fecal output was measured for determination of total tract digestion. Duodenal samples were taken during a four-day period to estimate nutrient flow. Ruminal fluid samples were collected at several times after feeding and analyzed for ammonia, volatile fatty acid (VFA) and pH. On day seven of each collection period, prior to morning feeding, rumens were evacuated to determine ruminal fill and to isolate bacterial samples via differential centrifugation for chemical analyses. All data were analyzed for statistical differences by analysis of variance.

Results and Discussion

Analyzed nutrient content of diets is provided in Table 1. As levels of DDGS increased, so did CP content of the diets.

Table 1. Diet composition and analyzed nutrient content of growing diets with increasing level of dried corn distillers grains with solubles.

	DDGS[1], % of dietary DM				
Item	0	15	30	45	60
Dry-rolled corn	58.0	43.0	28.0	15.0	—
DDGS[1]	—	15.0	30.0	45.0	60.0
Grass hay	30.0	30.0	30.0	30.0	30.0
De-sugared molasses	6.0	6.0	6.0	6.0	6.0
Sunflower meal	1.2	1.2	1.8	—	—
Urea	0.9	0.6	0.2	—	—
Supplement	4.0	4.2	4.0	4.0	4.0
	----------% DM basis----------				
Ash	10.6	10.3	10.8	11.1	11.6
CP	15.0	16.2	17.9	19.7	21.7
NDF	35.3	38.8	39.7	39.5	41.4
ADF	17.5	19.1	18.6	17.8	18.5

[1]Dried distillers grain with solubles.

Intake of OM responded in a quadratic manner ($P = 0.004$), with greatest intakes at 15 percent DDGS and lowest at 60 percent DDGS (Table 2). Similarly, Vander Pol et al. (2006) reported DMI of steers fed wet distillers grain with solubles (WDGS), partially replacing dry-rolled corn, was greatest at 30 percent inclusion, compared with 0 percent, 10 percent, 20 percent, 40 percent and 50 percent WDGS inclusion. Apparent and true ruminal OM digestion decreased (linear; $P \leq 0.009$), while post-ruminal OM digestion increased (linear; $P = 0.001$) with increasing DDGS inclusion. Total tract OM digestion was not affected ($P = 0.74$) by treatment, which agrees with other research in this area.

No differences were observed for CP intake ($P = 0.14$; Table 2), even though dietary CP increased with increasing DDGS. This is because steers fed increasing DDGS had decreased OM intakes. Total tract CP digestion increased (linear; $P < 0.001$) with increasing DDGS; however, no differences ($P \geq 0.67$) were observed for apparent ruminal, true ruminal or post-ruminal CP digestion. Treatment did not affect ($P = 0.22$) microbial efficiency.

Table 2. Effect of increasing level of dried corn distillers grains with solubles on OM and CP intake and digestion in growing diets offered to steers.

	DDGS[1], % of dietary DM							Contrast		
Item	0	15	30	45	60	SEM[2]	*P*-value[3]	Linear	Quadratic	Cubic
Organic Matter										
Intake, lbs./d	23.30	24.90	22.70	22.00	18.30	0.90	<0.001	<0.001	0.00	0.73
Digestibility, % of intake										
Apparent ruminal	61.30	59.70	55.90	50.50	50.90	3.00	0.09	0.01	0.83	0.41
True ruminal	62.10	60.50	56.70	51.40	52.00	3.00	0.10	0.01	0.80	0.41
Post-ruminal	14.20	17.00	21.70	27.10	26.00	2.50	0.02	0.00	0.47	0.32
Total tract	75.60	76.80	77.50	77.50	77.00	1.10	0.74	0.33	0.34	0.98
Crude Protein										
Intake, lbs./d	3.37	3.87	3.72	4.20	3.61	0.24	0.14	0.27	0.01	0.58
Digestibility, % of intake										
Apparent ruminal	12.20	18.90	12.10	16.80	9.80	9.90	0.93	0.82	0.65	0.95
True ruminal	48.30	51.40	47.20	47.90	43.90	6.70	0.94	0.56	0.71	0.90
Post-ruminal	55.60	52.00	61.70	61.30	67.30	8.30	0.67	0.21	0.76	0.79
Total tract	67.80	70.80	73.90	78.00	77.20	2.00	0.01	<0.001	0.35	0.41
Microbial efficiency	14.10	13.70	15.50	18.90	20.60	2.30	0.22	0.03	0.52	0.59

[1]Dried distillers grain with solubles.

[2]n = 5 observations per treatment.

[3]Probability value for the *F*-test of overall treatment.

As dietary DDGS increased, ruminal pH increased (linearly; $P = 0.004$; Table 3), while ammonia concentration remained unchanged ($P = 0.42$). Increased ruminal pH may be attributed to DDGS having less starch than corn. Starch from corn is degraded rapidly in the rumen; thus, it may decrease ruminal pH. Total VFA concentration decreased (linear; $P < 0.001$) with increasing DDGS inclusion. Ham et al. (1994) fed steers 40 percent WDGS, partially replacing dry-rolled corn, and reported no differences in pH or total VFA concentration when compared with steers consuming dry-rolled corn diets. Acetate proportions decreased ($P < 0.001$) with increasing DDGS, while propionate and butyrate were similar ($P \geq 0.19$), which resulted in a decreased (linear; $P < 0.001$) acetate-to-propionate ratio.

Table 3. Effect of increasing level of dried corn distillers grains with solubles on ruminal pH, ammonia and VFA in growing diets offered to steers.

	DDGS[1], % of dietary DM							Contrast		
Item	0	15	30	45	60	SEM[2]	*P*-value	Linear	Quadratic	Cubic
pH	6.42	6.35	6.64	6.60	6.61	0.06	0.01	0.00	0.63	0.17
Ammonia, m*M*	9.95	9.54	8.26	9.70	10.53	0.83	0.42	0.62	0.11	0.92
VFA										
Total, m*M*	97.60	99.90	86.90	85.70	83.30	3.20	0.01	<0.001	0.85	0.19
Acetate, mol/100 mol	59.50	59.10	55.50	53.90	53.30	0.90	<0.001	<0.001	0.63	0.19
Propionate, mol/100 mol	20.40	21.40	21.60	22.70	23.10	0.80	0.19	0.02	0.92	0.99
Butyrate, mol/100 mol	13.50	13.50	14.30	13.70	13.10	0.40	0.50	0.73	0.16	0.60
Acetate: propionate	2.95	2.81	2.58	2.39	2.34	0.13	0.02	<0.001	0.67	0.60

[1]Dried distillers grain with solubles.

[2]n = 5 observations per treatment.

Replacing dry-rolled corn with moderate to high levels of DDGS in growing diets resulted in no adverse effects on digestion or ruminal fermentation although OM intake was reduced at 60 percent DDGS inclusion.

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