The influence of grain source and fat level of distillers grain on in vitro enteric methane and carbon dioxide production, and ruminal pH in cattle

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The objectives of this study were to determine the influence of barley vs. corn based-diets and dried distillers grains with solubles (DDGS) of varying fat levels on in vitro methane and carbon dioxide production and ruminal pH. The results indicate no difference in total gas production or methane and carbon dioxide concentration among dietary treatments. Similarly, ruminal pH was not influenced by dietary treatment.

Summary

The current study utilized eight cannulated Holstein steers (1,576 ± 135.4 pounds) randomly assigned to four dietary treatments in a 2 × 2 factorial arrangement consisting of 1) rolled corn and low-fat dried distillers grain with solubles (DDGS), 2) rolled corn and moderate-fat DDGS, 3) rolled barley and low-fat DDGS and 4) rolled barley and moderate-fat DDGS. Diets were formulated to meet National Research Council (NRC) recommendations and were offered for ad libitum intake. The experiment was designed as a 4 x 4 Latin square with 24-day periods allowing for 10 days of intermediate dietary transition, seven days of dietary treatment acclimation and seven days of sample collection. Measurements included total gas production and in vitro enteric methane and carbon dioxide emission and ruminal pH. We found no difference in the amount or rate of in vitro total gas production among dietary treatments ($P \geq 0.28$) or concentration of methane and carbon dioxide produced ($P \geq 0.17$). Ruminal pH was not influenced by treatment ($P \geq 0.13$).

Introduction

Greenhouse gas emissions from ruminant animals result in inefficiencies of energy and nutrient utilization. Also, concerns over greenhouse gas emissions from ruminant animals are on the rise. Together, this creates a need for producers to implement methane-reducing strategies in cattle production systems. To maintain a steady meat and milk supply, researchers are focusing on the possibility of mitigating these gases through the use of alternative diets and feed sources.

Recently, ethanol plants have begun extracting additional oil from the DDGS, leading to a coproduct with less fat. Animals consuming these lower-fat DDGS may have greater methane production potential (and less overall net energy content) than those of animals consuming DDGS with greater fat. This could result in a product of lower feeding value.

Other common feed sources found in North Dakota include corn and barley. Researchers widely recognize that high-starch feeds in cattle diets decrease ruminal pH, favoring propionate production at the expense of acetate (Beauchemin et al., 2009). Thus, the availability of hydrogen is lowered, inhibiting the growth and activity of rumen methanogens (Van Kessel and Russell, 1996).

Studies comparing the effects of these grains on greenhouse gas production have shown that diets composed of corn result in decreased methane emission during the finishing phase vs. those of barley (Beauchemin et al., 2005). Less is known on the interaction of grain source and fat level in DDGS on methane production. Considering the impact of these grains and DDGS fat levels, our researche focused on determining the influence of these various feeds when provided in differing combinations.

Experimental Procedures

All procedures involving animals were approved by the NDSU Animal Care and Use Committee. Eight cannulated Holstein steers (1,576 ± 135.4 pounds) were assigned randomly to four dietary treatments in a 2 × 2 factorial arrangement consisting of 1) rolled corn and low-fat dried distillers grain with solubles (DDGS), 2) rolled corn and moderate-fat DDGS, 3) rolled barley and low-fat DDGS and 4) rolled barley and moderate-fat DDGS (Table 1).

Diets were formulated to meet NRC recommendations and were offered for ad libitum intake. The experiment was designed as a 4 x

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4 Latin square with 24-day periods allowing for 10 days of intermediate dietary transition, seven days of dietary treatment acclimation and seven days of sample collection. Gas production was examined on days 1 and 7 of the collection period using an Ankom gas pressure monitoring system and four replicates per treatment to measure the changes in pressure relative to atmospheric pressure as a consequence of gas produced during fermentation.

Measurements of gas production were monitored for a period of 72 hours. After 24 hours, methane and carbon dioxide concentration was quantified using a gas chromatograph. Approximately 200 milliliters (mL) of rumen fluid was collected from days 3 to 5 in a manner to represent every other hour in a 24-hour cycle, and pH was measured immediately after collection. Data were analyzed using the MIXED procedure of SAS, with statistical significance declared at $P \leq 0.05$.

Table 1. Dietary composition.

	Rolled Corn		Rolled Barley	
Dietary Component, % of DM	Low Fat DDGS	Moderate Fat DDGS	Low Fat DDGS	Moderate Fat DDGS
Rolled corn	50	50		
Barley			50	50
DDGS	25	25	25	25
Corn silage	20	20	20	20
Limestone	2	2	2	2
Urea	0.15	0.15		
Salt	0.05	0.05	0.05	0.05
Vitamin premix	0.01	0.01	0.01	0.01
Mineral premix	0.05	0.05	0.05	0.05
Rumensin	0.02	0.02	0.02	0.02
Tylan	0.01	0.01	0.01	0.01
Fine-ground corn	2.46	2.46	2.61	2.61
Chromium oxide	0.25	0.25	0.25	0.25
Analyzed nutrient concentration of diets (DM basis)				
Dry matter, % of as fed	67.6	66.3	65.1	65.9
Organic matter, % of DM	94.0	93.9	93.7	93.8
Crude protein, % of DM	6.01	6.09	6.32	6.19
Neutral detergent fiber, % of DM	14.8	15.3	15.4	15.4
Acid detergent fiber, % of DM	26.2	29.6	28.5	31.0
Ether extract, % of DM	9.46	10.1	11.0	11.6
Calcium, % of DM	2.54	2.60	2.39	2.35
Phosphorus, % of DM	0.940	1.09	0.939	0.856
Starch, % of DM	3.24	4.35	2.35	3.03

Results and Discussion

We found no difference in total gas production among dietary treatments ($P > 0.1$; Table 2). The concentration of methane and carbon dioxide produced was not affected ($P = 0.22$) by dietary treatment. Ruminal pH also was not influenced ($P = 0.13$) by dietary treatment (Figure 1).

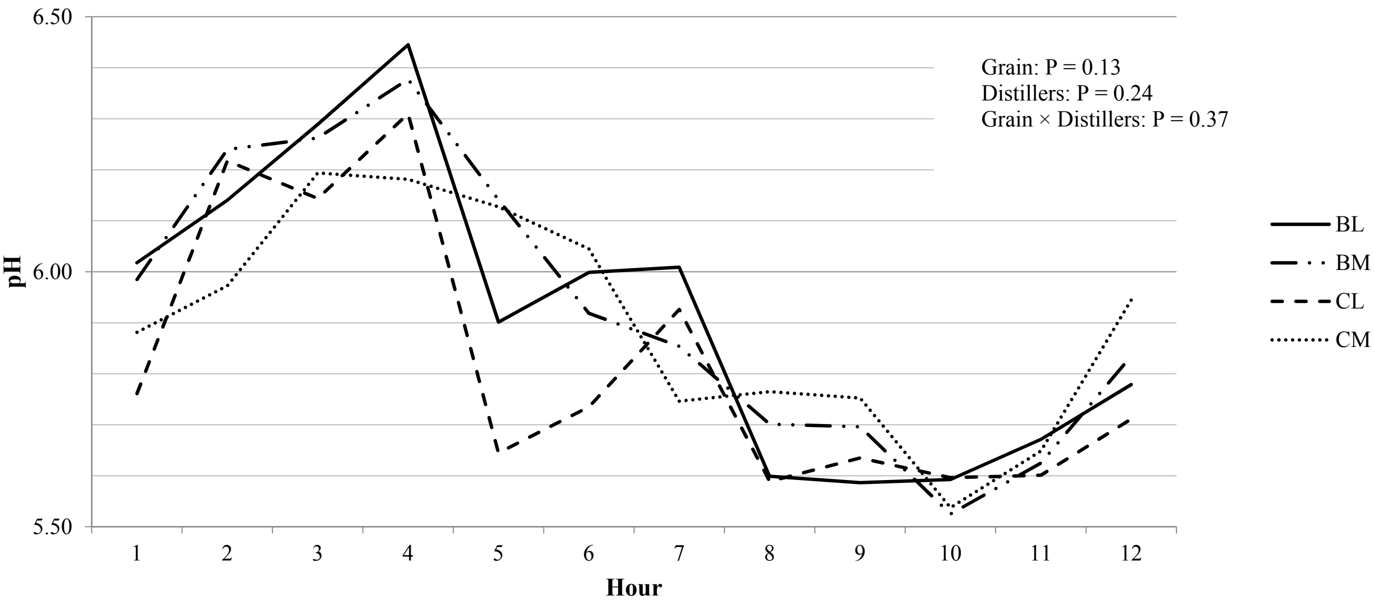
The majority of studies have indicated reduced methane production with corn-based diets and increasing levels of fat (Massé et al., 2014, Hünerberg et al., 2013). Typically, this will occur due to the inhibited growth of the rumen protozoa and reduction of methanogens (Knapp et al., 2014). Surprisingly,

Table 2. Gas production and in vitro methane concentration of steers fed corn vs. barley with low vs. moderate fat DDGS[a].

	Rolled Corn		Rolled Barley			*P*-values		
	Low Fat DDGS	Moderate Fat DDGS	Low Fat DDGS	Moderate Fat DDGS	SEM	Grain	DDGS	Grain × DDGS
Gas Production, mLs								
A	50.26	43.13	45.81	42.49	6.321	0.69	0.41	0.76
C	0.302	0.282	0.217	0.233	0.0618	0.28	0.98	0.77
d	-1.21	-1.13	-0.843	-1.09	0.2519	0.43	0.75	0.52
L	3.82	3.91	3.37	3.79	0.729	0.70	0.73	0.82
Methane, % of gas	22.2	24.8	24.4	23.3	1.58	0.80	0.61	0.22
CO_2, % of gas	59.4	55.8	57.1	54.5	2.16	0.41	0.17	0.84
CH_4:CO_2	0.385	0.462	0.443	0.440	0.0333	0.57	0.25	0.22

[a] Data are presented as least square means per treatment ± SEM, n = 4 per treatment, A = asymptote, C = rate, L = lag

Figure 1. Ruminal pH of steers fed corn vs barley with low vs moderate fat DDGS.



*BL - Barley with low-fat DDGS; BM - Barley with moderate-fat DDGS; CL - Corn with low-fat DDGS; CM - Corn with moderate-fat DDGS

however, the current study demonstrates no effect despite the variation in grain and DDGS fat levels. This outcome may be the result of differences in experimental design, feed composition, the fat sources used or the number of animals involved in the trial.

Concentrations of CO_2 and the ratio of CH^4-to- CO_2 also were not impacted by treatment. This may not be surprising because the pH of rumen fluid did not differ between treatments, suggesting that the alternative diets used in this study may not have greatly influenced rumen fermentation or allowed for excess free hydrogen, which then would have been available for methane production. What is interesting to note, however, is that the highest pH measurements occurred between 6 and 7 a.m.

We believe this was due to increased salivation acting as a buffer. Although the animals were provided with ad libitum feed, bunks were cleaned and rations replaced every morning during this time. Also during this time, the animals were most active and consumed the greatest portion of feed.

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