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Summary

Methane production was measured following the replacement of corn with DDGS in vitro and also after the simultaneous replacement of corn and corn oil with DDGS (for 30% of the diet) in vivo. In vitro substitution of corn with DDGS increased the amount of methane produced per milligram of DM digested. Likewise, in vivo methane production was increased by 44% when corn and corn oil were replaced with DDGS. The greater energy value of DDGS relative to corn in a concentrate-based diet is not due to decreased methanogenesis.

Introduction

The inclusion of DDGS in a corn-based diet results in the DDGS possessing a greater amount of net energy available for gain relative to the corn it replaces, and this increase may be attributed to a decrease in ruminal methane production. DDGS contains a greater amount of fat than does corn, and some fatty acids predominant in corn oil have been reported to specifically inhibit methanogenesis. Furthermore, DDGS contains a lesser amount of fermentable substrates than does corn. We hypothesized that the replacement of corn with DDGS would decrease ruminal methane production.

Procedure

In vitro methane production

Ruminal fluid collected from a fistulated heifer receiving a mixed forage and concentrate diet was used to inoculate cultures (n = 4/substrate combination) provided with one of five substrate combinations at a rate of 10 mg DM/mL. Substrate combinations were 100% corn (0%), 25% DDGS and 75% corn (25%), 50% DDGS and 50% corn (50%), 75% DDGS and 25% corn (75%), or 100% DDGS (100%). Nutrient content of the substrates is outlined in Table 1. Cultures also contained a modified McDougall's buffer, distilled H_2O, trypticase, resazurin, a micro mineral solution, and Na_2S. Following the addition of media to 40 mL glass vials, an oxygen-free environment was created by purging each of the cultures with CO_2. The vials were then sealed, pressurized to 100 kPa above atmospheric pressure, and placed in a shaking incubator (102°F) for 22 hours. Following incubation, headspace pressure was measured and methane concentration was determined using a gas chromatograph. Media were then centrifuged and the supernatant was removed for volatile fatty acid (VFA) concentration analysis. IVDMD was determined by filtration and subsequent drying of the filter (140°F) for 48 hours. Data were analyzed using direct regression in order to determine the significance of the linear and quadratic effects of DDGS inclusion level.

Table 1. Nutrient content of substrates (%DM; in vitro experiment).

	Substrate	
Nutrient Content	DDGS	Fine ground corn
Neutral detergent fiber	27.3	18.7
Starch	8.17	1.6
Crude protein	29.3	10.6
Ether extract	9.9	3.7

Table 2. Diet composition and nutrient content (%DM; sheep experiment).

	Diet	
Composition of Pellets	CORN	CORN/DDGS
Fine ground corn	71.4	43.7
DDGS	0.0	29.9
Alfalfa	10.0	10.0
Brome hay	10.0	10.0
Mineral	2.5	2.5
Ammonium chloride	2.5	2.5
Corn oil	2.2	0.0
Lignin sulfonate	1.4	1.4
Nutrient Content		
Starch	56.6	44.6
NDF	17.5	26.5
CP	14.3	18.5
EE	4.0	6.1

Lamb experiment

Nine crossbred lambs (38 ± 7 lb) were assigned randomly to receive a sequence of diets in a 2-period crossover design. Lambs were fed twice daily and at 3% of BW. Diets contained 71% corn, 2% corn oil, and 27% forage and supplement (CORN) or DDGS replaced both corn and corn oil for 27.7% and 2.2%, respectively, of the diet (CORN/DDGS). Diet compositions and nutrient contents are outlined in Table 2. Lambs were adapted to grain by feeding 50%, 40%, 35%, and 30% forage and supplement (DM basis) replaced by concentrate (corn or corn/DDGS) for 4, 4, 4, and 2 days, respectively, prior to the commencement of feces collection. Periods were 19 days with 14 days of adaptation and 5 days of collecting orts and feces for determination of DM digestibility. Methane production was determined on days 17 and 18 of each period using the sulfur hexafluoride tracer technique, which was described previously (2007 *Nebraska Beef Report*, pp. 19-21). Ruminal fluid was collected via the esophagus at 1200 hour on day 19. The pH of the samples was recorded and samples were immediately frozen for later VFA analysis. Data were analyzed utilizing the MIXED procedure of SAS. The model included the fixed effects of period, diet, and day of sampling and the random effect of animal. Because the same animal was sampled twice, each period a repeated measures covariance structure was used.

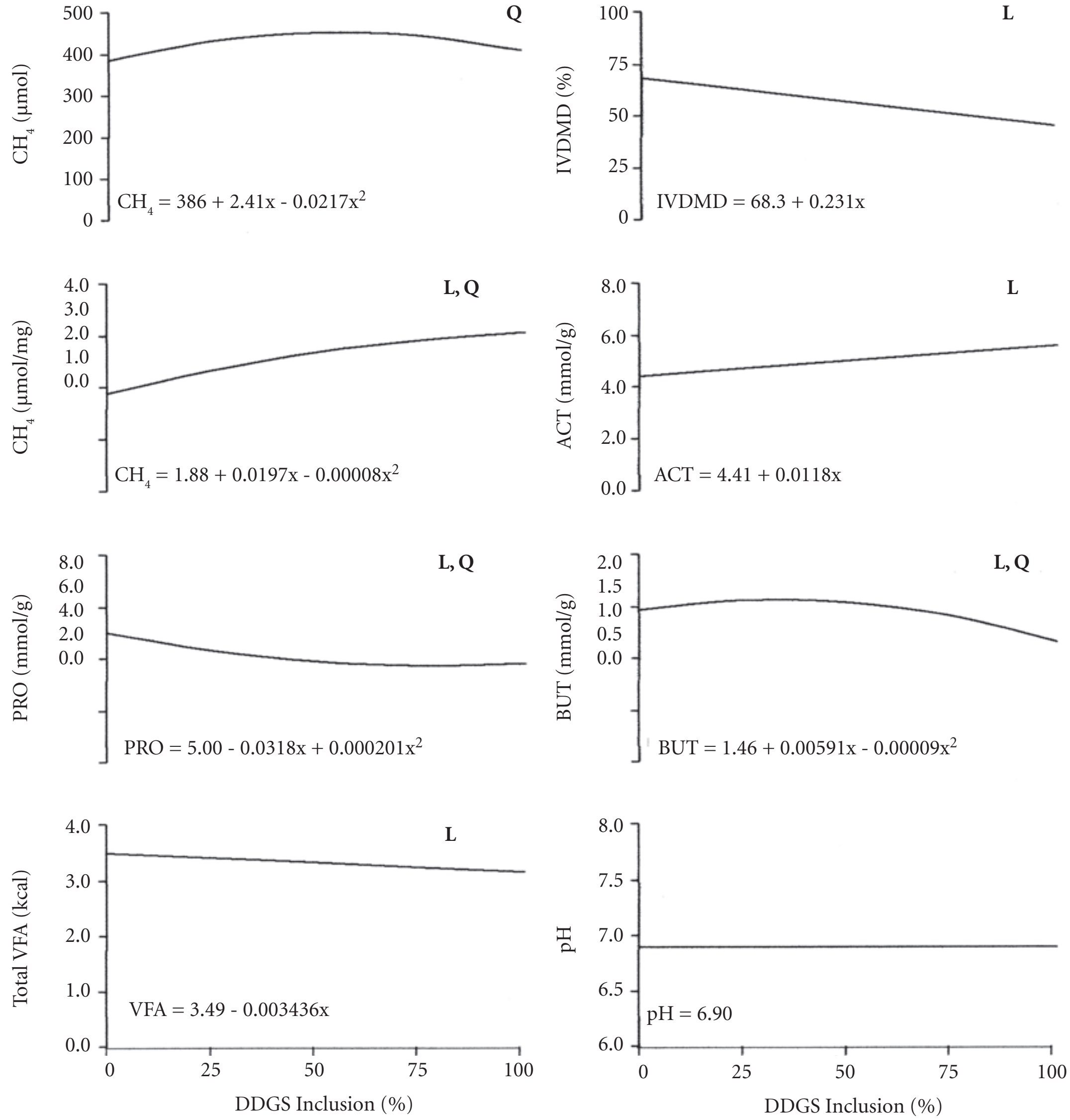

Figure 1. L = linear coefficient was significant (P < 0.05), Q = quadratic coefficient was significant (P < 0.05). Response curves for total methane (CH_4) production, IVDMD (in vitro dry matter digestibility), CH_4 production per mg of digestible DM, acetate (ACT) production, propionate (PRO) production, butyrate (BUT) production, total kcal produced in the form of VFA calculated as (0.209*ACT)+(0.367*PRO)+(0.524*BUT), and final culture pH when DDGS replaced corn as a substrate for in vitro fermentation.

Results

In vitro methane production

The complete replacement of corn with DDGS did not affect the total amount of methane produced by cultures (Figure 1). As DDGS was substituted for corn, IVDMD decreased ($P < 0.01$). The decrease in DM digested as DDGS replaced corn resulted in an increase ($P < 0.01$) in the amount of methane produced per milligram of digested substrate. Consistent with commonly observed fermentation patterns, replacement of the substrate composed predominantly of starch (corn) with a more fibrous substrate (DDGS) resulted in an increase ($P < 0.01$) in the amount of acetate produced per milligram of digested DM but a decrease ($P < 0.01$) in the amount of propionate and butyrate produced per milligram of digested DM. The kcal of energy available from the VFA produced per milligram of digested DM decreased ($P < 0.05$) as corn was replaced with DDGS. The latter observation is likely a function of the greater amount of non-fermentable substrate (ether extract, and protein) present in the DDGS compared to corn, which decreases the amount of fermentable substrate (fiber and starch) available for VFA production.

Lamb experiment

DMI was greater ($P = 0.03$) for the CORN diet but no difference in digestibility was detected (Table 3). The simultaneous replacement of corn and corn oil with DDGS resulted in a 29% increase ($P = 0.02$) in methane

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emissions. Likewise, methane emissions per lb of digested DM increased (P = 0.01) 44% when corn and corn oil were replaced with DDGS. The pH of collected ruminal fluid tended to be lesser (P = 0.06) for CORN/DDGS animals compared to CORN animals, but no differences were detected in the concentrations of acetate, propionate, or butyrate.

The increase in methane production observed in vitro and in vivo can be attributed to the accompanying increase and decrease in NDF and starch, respectively, because fiber possesses a greater methanogenic potential than starch. One caveat to our interpretation involves potential effects of oil. Both diets contained corn oil but the physical form of this oil in DDGS may affect methanogenesis differently than the physical form of added oil in the CORN diet. We conclude that a decrease in methane production is not responsible for the increased energy value of DDGS when it is used to replace corn in a feedlot diet.

Table 3. Effects of simultaneously replacing corn and corn oil with DDGS.

	Diet			
Variable	CORN	CORN/DDGS	SEM	*P*-value
DMI (lb)	1.34	1.28	0.08	0.03
DM Digestibility (%)	78.1	75.8	1.3	0.15
CH_4 (mL/min)	10.2	13.2	2.0	0.02
CH_4 (mL/min • lb)[a]	9.48	13.7	1.7	0.01
pH	5.85	5.49	0.14	0.06
Acetate (mM)	24.3	24.3	2.4	0.99
Propionate (mM)	17.0	14.3	2.1	0.37
Butyrate (mM)	6.79	6.12	1.33	0.69

[a]CH_4 production rate per lb of digested DM.

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