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Reduced-fat dried distillers grains with solubles reduces the risk for milk fat depression and supports milk production and ruminal fermentation in dairy cows

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ABSTRACT

Twenty Holstein cows, 12 primiparous and 8 multiparous, with (mean ± SD) 91 ± 19 d in milk and 595 ± 81 kg were used in replicated 4 × 4 Latin squares to compare the effects of feeding conventional dried distillers grains with solubles (DDGS) and reduced-fat DDGS (RFDDGS) in combination with rumen-inert fat (RIF) on milk production and rumen fermentation; one square contained rumen cannulated animals for rumen measurements. In each 21-d period, cows were randomly assigned to 1 of 4 dietary treatments (values on a dry matter basis): (1) control (CON) that contained 0% DDGS; (2) DG contained 30% DDGS; (3) RFDG contained 30% RFDDGS in substitution of DDGS; and (4) RFDG+RIF was similar to RFDG with the addition of 1.9% RIF. Unlike most practical diets in the dairy field, our diets had <22% forage neutral detergent fiber and >18.0% crude protein. Dry matter intake was similar across treatments with any form of DDGS averaging 26.0 ± 0.6 kg/d, whereas the CON diet resulted in less dry matter intake, 21.6 ± 0.6 kg/d. Milk yield tended to be 1.7 kg/d greater for diets with either type of DDGS. Concentration of milk protein was greatest for the DG and RFDG diets, intermediate for the RFDG+RIF diet, and least for the CON diet, namely 3.22, 3.21, 3.12, and 3.07 ± 0.05%. Reduced milk fat percentage and yield were observed when cows consumed the DG diet, 3.27 ± 0.10% and 1.11 ± 0.04 kg/d, respectively, whereas these responses were similar among CON, RFDG, and RFDG+RIF, which averaged 3.68 ± 0.10% and 1.22 ± 0.04 kg/d. The presence of *trans*-10,*cis*-12 conjugated linoleic acid was only detected in milk from cows consuming the DG diet; similarly, concentration and yield of *trans*-10 18:1 were greater for cows consuming this diet. Rumen ammonia was similar across treatments averaging 27.0 ± 2.1 mg/dL. The CON and RFDG+RIF diets had similar mean pH, 6.1 ± 0.11, whereas DG and RFDG resulted in lower pH averaging 5.79 ± 0.11. No effect on total concentration of volatile fatty acids was observed; the overall mean was 121 ± 4.11 m*M*; molar proportion of acetate was affected by treatment resulting in 67.3, 63.2, 61.4, and 60.9 ± 0.93 mol/100 mol for CON, RFDG+RIF, RFDG, and DG, respectively. Results from DNA sequencing showed that rumen bacterial community structure was relatively stable with minor changes at the family and genus levels; these changes may be associated with low starch diets, and hence reduced amylolytic bacteria populations. Feeding high proportions of RFDDGS resulted in greater dry matter intake with low risk for milk fat depression while supporting ruminal fermentation.

Key words: corn milling, milk fat, rumen bacteria

INTRODUCTION

Utilization of co-products from the corn ethanol industry has received a great deal of attention by the animal industry and has been extensively researched in feeding systems of food-producing animals (Klopfenstein et al., 2008; Schingoethe et al., 2009). Dried distillers grains with solubles (**DDGS**) are a source of energy and protein for ruminants (Ham et al., 1994). This feedstuff has been shown to be effective in increasing animal performance as well as being economical as it can effectively replace more expensive sources of protein and energy (Buckner et al., 2008; Ranathunga et al., 2010). Research suggests a safe inclusion level of

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DDGS in dairy diets of up to 20% DM basis (Anderson et al., 2006; Kleinschmit et al., 2006) and even up to 30% (Janicek et al., 2008) with no deleterious effects on milk production and milk composition. Nonetheless, some researchers (Abdelqader et al., 2009) have reported milk fat depression (**MFD**) when feeding DDGS and observed a relationship to high content of free PUFA in the diet. Milk fat depression is a condition characterized by a reduction in milk fat yield with no additional effects on other productive traits such milk yield or milk protein yield (Bauman and Griinari, 2001). This physiological phenomenon is associated with ruminal bacterial biohydrogenation of PUFA. During this process, bacteria produce bio-active isomers of CLA that inhibit synthesis of fatty acids within the mammary gland as well as uptake of fatty acid from the bloodstream (Chouinard et al., 1999; Peterson et al., 2003). This condition is prevalent when ruminal conditions include a high load of PUFA and low pH (Kalscheur et al., 1997a,b). Lately, the corn ethanol industry has adopted technologies to extract a portion of the fat in the co-product stream (Majoni et al., 2011), which results in production of reduced-fat DDGS (**RFDDGS**). The efficiency of fat extraction varies depending on the technology of each ethanol plant, but in general, the ether extract content of RFDDGS is approximately 50 to 60% of that in DDGS. This product may prove to be a more effective feedstuff for the dairy industry because the reduced content of PUFA may decrease the risk for MFD. In fact, recent studies have reported successful feeding of RFDDGS in dairy cattle diets at 20% of dietary DM (Mjoun et al., 2010a; Castillo-Lopez et al., 2014b). This co-product is a relatively new feedstuff and its effects on lactational performance, rumen metabolism, and ruminal bacterial community structure need to be further investigated.

Ruminal microbial community structure and metabolism of unsaturated fatty acids under altered rumen environmental conditions influence the development of MFD. Weimer et al. (2010) examined the community dynamics of 4 pairs of cows fed MFD-inducing diets. They identified changes in bacterial community structure between cows that responded to a MFD-inducing diet and cows who did not respond to the treatment. The authors suggested that specific combinations of taxa might elicit MFD. Similarly, Ramirez-Ramirez et al. (2012) reported that feeding dairy cows a highly fermentable diet including 30% DDGS (DM basis) resulted in MFD and modified the bacterial community structure in rumen fluid. We hypothesize that feeding RFDDGS will reduce the risk of MFD because the removal of oil may lead to lesser accumulation of bio-active isomers of CLA; therefore, our objectives were (1) to determine the effect of RFDDGS on milk production and composition, and (2) to use DNA pyrosequencing of 16S amplicons to investigate and describe microbial community in the rumen during MFD and its potential effects on metabolism of PUFA.

MATERIALS AND METHODS

Animal Care, Housing, and Feeding

Experimental cows were cared for according to the guidelines stipulated by the University of Nebraska Animal Care and Use Committee. Cows were housed in individual stalls and milked at 0730 and 1930 h. Cows were individually fed once a day at 0900 h for ad libitum consumption to allow for approximately 10% refusals, which were collected, weighed, and recorded individually. Days 1 to 14 of each period were considered as an adaptation period; milk production and DMI data collected during the last 7 d were considered for statistical analyses.

Animals, Experimental Design, and Treatments

Twenty Holstein cows, 12 primiparous and 8 multiparous, averaging (±SD) 91 ± 19 DIM and 595 ± 81 kg of BW were used in replicated 4 × 4 Latin squares with 21-d periods and randomly assigned to treatments. One of the squares contained 4 ruminally cannulated cows that were used for measurements of rumen pH, concentration of ammonia and VFA, and bacterial community structure. All squares were used to test the effect of treatments on milk production and composition, and feed intake. During each period, cows were offered 1 of 4 TMR (ingredients listed in Table 1; TMR formulations listed in Table 2) that included conventional DDGS, RFDDGS, or RFDDGS supplemented with rumen inert fat (**RIF**; calcium salts of long-chain fatty acids, Megalac, Church & Dwight Co. Inc., Princeton, NJ). Fat extraction to produce the RFDDGS fed in this study was by centrifugation of the condensed solubles component (POET Nutrition Inc., Sioux Falls, SD). Dietary treatments were (DM basis): (1) control diet (**CON**) with 0% DDGS, (2) **DG** with 30% DDGS, (3) **RFDG** with 30% RFDDGS, and (4) **RFDG+RIF** with 30% RFDDGS supplemented with 1.9% RIF. Diets were formulated to compare milk production when diets included DDGS or RFDDGS. The addition of RIF was used to evaluate if supplemental energy is needed to compensate for fat removal in RFDDGS.

Sampling and Data Collection

Feed Sampling. Samples of each TMR, forages, and concentrates were collected on d 20 and 21 of