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Fat and starch as additive risk factors for milk fat depression in dairy diets containing corn dried distillers grains with solubles

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ABSTRACT

Two experiments were conducted to evaluate the additive effects of starch and fat as risk factors associated with milk fat depression in dairy diets containing corn dried distillers grains with solubles. In experiment 1, 4 multiparous ruminally cannulated Holstein cows, averaging 114 ± 14 d in milk and 662 ± 52 kg of body weight, were randomly assigned to 4 treatments in a 4 × 4 Latin square to determine the effect of these risk factors on rumen fermentation and milk fatty acid profile. In each 21-d period, cows were assigned to 1 of 4 dietary treatments: a control diet (CON; ether extract 5.2%, starch 19%); CON with added oil (OL; ether extract 6.4%, starch 18%); CON with added starch (STR; ether extract 5.5%, starch 22%); and CON with added oil and starch (COMBO; ether extract 6.5%, starch 23%). After completion of experiment 1, milk production response was evaluated in a second experiment with a similar approach to diet formulation. Twenty Holstein cows, 12 primiparous and 8 multiparous, averaging 117 ± 17 d in milk and 641 ± 82 kg, were used in replicated 4 × 4 Latin squares with 21-d periods. Results from experiment 1 showed that ruminal pH was not affected by treatment averaging 5.87 ± 0.08. Molar proportion of propionate in rumen fluid was greatest on the COMBO diet, followed by OL and STR, and lowest for CON. The concentration of *trans*-10,*cis*-12 conjugated linoleic acid in milk fat increased with the COMBO diet. Adding oil, starch, or a combination of both resulted in lower concentration and yield of fatty acids <16 carbons. Compared with the control, OL and STR resulted in 13% lower concentration, whereas the COMBO diet resulted in a 27% reduction; similarly yield was reduced by 24% with the OL and STR treatments and 54% with the COMBO diet. In experiment 2, milk yield, milk protein percentage, and milk protein yield were similar across treatments, averaging 26.6 ± 1.01 kg/d, 3.2 ± 0.05%, and 0.84 ± 0.03 kg/d, respectively. Fat-corrected milk was greatest for CON, 26.5 ± 1.12 kg/d; no differences were detected among the remaining treatments, which averaged 23.5 ± 1.12 kg/d. Milk fat percentage was greatest when cows consumed CON, 3.3 ± 0.15%; OL and STR averaged 3.0 ± 0.15% and COMBO resulted in the lowest milk fat percentage, 2.73 ± 0.15%. Milk fat yield was 0.25 ± 0.05 kg/d greater for the CON diet compared with the other 3 treatments, which were similar. These results suggest that fat and starch are additive risk factors that will likely induce milk fat depression in diets containing high inclusion of dried distillers grains with solubles.

Key words: corn milling co-product, milk fat, milk fatty acid

INTRODUCTION

The production of ethanol from corn has rapidly grown, and, as a result, more animal feed co-products are available for the dairy industry (Renewable Fuels Association, 2013). Dried distillers grains with solubles (**DDGS**) are one example of these co-products and are usually a cost-effective source of protein (Liu, 2011; Paz et al. 2013) and energy for ruminants (Ham et al., 1994). Research has shown that dairy diets may contain 20% DDGS (DM basis) while maintaining or even increasing milk yield (Anderson et al., 2006; Kelzer et al., 2009; Schingoethe et al., 2009). Conversely, some authors have reported milk fat depression (**MFD**) when feeding DDGS (Abdelqader et al. 2009). Therefore, in commercial settings, the inclusion of this ingredient may be minimized to avoid MFD (Janicek et al., 2008; Hollmann et al., 2011).

Milk fat depression is a disorder characterized by normal milk production with low milk fat concentration (Bauman et al., 2008). This condition may develop due to the production and accumulation of bioactive isomers of CLA in the rumen during microbial biohydrogenation. Among others, the *trans*-10,*cis*-12 CLA isomer has been reported to be a potent suppressor of

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mammary uptake and de novo synthesis of FA (Chouinard et al., 1999; Baumgard et al., 2000). Furthermore, flow of these FA out of the rumen is increased when cows consume increasing amounts of long-chain PUFA (Bauman and Griinari, 2003). Additionally, Kalscheur et al. (1997a) reported MDF and increased production of *trans*-10 C18:1, a putative source of *trans*-10,*cis*-12 CLA, with diets high in starch from ground corn which lead to low ruminal pH. Because they contain a high concentration of PUFA, DDGS are often believed to be associated with MFD. However, it is likely that the extent to which DDGS cause MFD is related to other ingredients included as well as the type of fat (Kalscheur et al., 1997b) in the ration. Therefore, we hypothesized that feeding DDGS in a TMR with high starch content may predispose cows to undergo MFD due to increased ruminal fermentation and acidosis. Furthermore, the addition of corn oil would exacerbate this response by altering biohydrogenation of PUFA. Thus, the present study was designed to investigate the effects of increasing starch and PUFA to a control diet containing DDGS on rumen fermentation, milk production, and composition.

MATERIALS AND METHODS

Animal Care, Housing, and Sampling

Our study involved 2 experiments in which the experimental cows were cared for according to the guidelines stipulated by the University of Nebraska-Lincoln Animal Care and Use Committee. The following conditions were identical in both experiments. Cows were housed in individual stalls and milked at 0730 and 1930 h. Cows were individually fed at 0900 h for approximately 110% ad libitum consumption. Orts were collected, weighed, and recorded individually. Day 1 to 14 of each period were considered as an adaptation period; data collected during the last 7 d were considered for statistical analyses. Body weight and BCS (1 to 5 scale) were measured on d 20 and 21 of each period. Body condition score was measured by a single, trained individual, and the scoring method used was similar to that of Wildman et al. (1982) but reported to the quarter point.

Experiment 1: Animal, Experimental Design, and Treatments

A ruminal fermentation study was conducted with 4 multiparous ruminally cannulated Holstein cows averaging (±SD) 114 ± 14 DIM and 662 ± 52 kg of BW in a 4 × 4 Latin square with 21-d periods. Cows were randomly assigned to 1 of 4 experimental treatments (on a DM basis): a control diet (**CON**), 2 other treatments similar to CON but containing 0.97% corn oil (**OL**) or 8.5% additional ground corn (**STR**) as risk factors for MFD, and a fourth treatment containing 0.97% corn oil and 7.6% additional ground corn (**COMBO**) as a combination of risk factors. All diets contained DDGS at 20% (DM basis; Table 1). The forage-to-concentrate ratio of all diets was 53:47 with 23% forage NDF (as a % of dietary DM). When formulating the OL, STR, and COMBO treatments, soy hulls were removed from the CON formulation to allow inclusion of corn oil and ground corn.

Sampling and Data Collection

Feed Sampling. Research farm employees collected data on a daily basis, whereas feed sampling was performed by the researchers to coincide with rumen sampling and optimize resources. Samples of each TMR and forages were collected on d 20 and 21 of each period and subsequently pooled by period. The Penn State Forage Particle Separator (Nasco, Fort Atkinson, WI) was used to measure particle size distribution of the different TMR as described by Kononoff et al. (2003). Feed samples were dried at 55°C in a forced-air oven to determine DM. After determination of DM, samples were ground (1-mm screen; Wiley mill, Arthur H. Thomas Co., Philadelphia, PA) and stored at room temperature. Concentration of FA and profile were determined by GC-flame-ionization detection after direct methylation (Sukhija and Palmquist, 1988) on composite TMR samples using C13:0 or C17:1 (NuChek Prep Inc., Elysian, MN) as internal standards, as described by Rico et al. (2014).

Milk Data Collection. Individual milk production was measured and recorded daily by an automatized computer program for data collection; measurements from the last 7 d of each period were used to evaluate milk production; additionally, milk samples were collected during the morning and evening milking of d 19, 20, and 21 by farm employees and preserved using a pellet of 2-bromo-2-nitropropane-1,3-diol. Milk samples were analyzed for fat, true protein, lactose, and SNF (AOAC International, 2000) by Heart of America DHIA (Manhattan, KS) using a B2000 Infrared Analyzer (Bentley Instruments, Chaska, MN). Milk urea nitrogen was determined by the same laboratory using a modified Berthelot reaction concentration using a ChemSpec 150 Analyzer (Bentley Instruments). Yields of milk components were estimated according to milk weight and time of collection. During the last 7 d of each period, daily DMI and milk yield were averaged. An additional milk sample was taken at the times previously described for determination of FA profile. Individual samples were frozen immediately after milking,