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Effects on lactating dairy cows of oscillating dietary concentrations of unsaturated and total long-chain fatty acids

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ABSTRACT

The nutrient composition of diets can vary from batch to batch because of variation in the nutrient composition of ingredients. The concentration of fat in distillers grains can be highly variable and, coupled with a high dietary inclusion rate, can result in substantial variation in the fat concentration of the total diet. Our hypothesis was that variation in dietary fat concentrations over short periods would have negative effects on production measures of dairy cattle. Twenty-four Holstein cows were used in 8 truncated Latin squares (3 cows × 2 periods). Periods were 16 d long, with a 12-d washout period separating the 2 periods. The 3 treatments were 1) control, 2) moderate variation, and 3) high variation. The control treatment was a consistent diet over the 16 d and contained 5.8% (dry basis) total long-chain fatty acids (LCFA), 23.7% distillers grains, and 1.1% of dry matter as corn oil. The average concentration of LCFA over the 16-d period for the moderate variation and high variation treatments was also 5.9%, but concentrations of LCFA varied over time by the addition or removal of corn oil. The moderate variation treatment had a 4-d phase of 5.4% LCFA, followed by a 4-d phase with 6.4% LCFA to complete the cycle, and then the cycle was repeated. The high variation treatment followed the same cycle pattern, but concentration of LCFA was either 4.8 or 7.0%. Over the 16 d, dry matter intake and milk yield were significantly decreased by the high variation treatment (intake = 21.7, 21.8, and 20.7 kg/d; milk = 36.4, 37.6, and 35.4 kg/d for the control, moderate variation, and high variation treatments). The effect of variation appeared to be cumulative; differences were not significant in the first 8-d cycle but were in the second 8-d cycle. Milk fat concentration was low (2.4%) and was not affected by treatment or cycle × treatment. The concentration of *trans*-10 C18:1 in milk fat was very high (4.2% of total milk fatty acids) but was not affected by treatment. However, cows on the high variation treatment had higher concentrations of *trans*-10, *cis*-12 C18:2 in milk fat (0.036, 0.042, and 0.047% of milk fatty acids for the control, moderate variation, and high variation treatments). Overall, an extreme short-term fluctuation in dietary fat concentration was needed before negative effects were observed.

Key words: distillers grains, milk fatty acid, supplemental fat, variation

INTRODUCTION

All feedstuffs vary in their nutrient composition because of plant genetics, growing conditions, harvest and storing systems, and manufacturing differences, among others. The composition of both concentrates and forages can change significantly over short periods of time (Weiss et al., 2012), and that could cause substantial short-term changes in TMR composition. The effects of short-term changes in the nutrient composition of diets have not been studied, with the exception of oscillating concentrations of dietary CP (i.e., a short period of high CP followed by a short period of low CP repeated in a cyclic pattern) fed to beef cattle and sheep (Cole, 1999; Ludden et al., 2002; Cole et al., 2003). In general, growth and nutrient utilization measures of animals fed the oscillating protein diets were equal or slightly improved compared with animals fed a constant CP diet that was approximately equal to the average CP of the oscillating treatment.

Because of the burgeoning ethanol industry in the United States, distillers grains are becoming a common ingredient in dairy diets. However, numerous surveys have shown that the nutrient composition of distillers grains can be quite variable, depending on the source and other factors (Belyea et al., 1989; DePeters et al., 2000; Spiehs et al., 2002; Buckner et al., 2011). Within a survey, average fat concentrations among distilleries have ranged by as much as 4 percentage units, and within-distillery coefficients of variation have been as high as 12% (Spiehs et al., 2002). A large national feed-testing laboratory reported an average fat concentration in dried distillers grains (4,819 samples) of 12.6%

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with a standard deviation of 3.2 (Dairy One, 2011). The majority of fat in dried distillers grains is unsaturated (Abdelqader et al., 2009), and excess unsaturated FA can have negative effects on dairy cows (Harvatine and Allen, 2006). We hypothesized that diets with short-term variation (days) in the concentration of unsaturated FA would negatively affect cows even though, across a few weeks, the average concentration of unsaturated FA would be equal to a diet with a consistent day-to-day concentration of unsaturated FA.

MATERIALS AND METHODS

Cows, Diets, and Experimental Design

Twenty-four Holstein cows (average DIM = 140 d; SD = 22 d) were blocked into groups of 3 by parity (3 blocks of first-parity cows and 5 blocks of multiparous cows) and milk production, and each block was used in 1 of 8 truncated (3 cows × 2 periods) Latin squares. The first 4 squares were conducted concurrently, and when they were completed, the next 4 squares were conducted (the 2 groups of squares are designated as a group in the statistical model). Periods were 16 d long, and a washout period of 12 d separated the 2 periods. All cows were moved into the tie-stall barn and fed a preliminary diet for 8 d (this diet was also fed during the washout period between the 2 treatment periods). The preliminary diet (DM basis) was 38% corn silage, 20% alfalfa silage, 17% corn gluten feed, 14.6% ground corn grain, 7.4% soybean meal, 2.7% mineral-vitamin premix, and 0.3% animal-vegetable blend fat and contained 3.0% long-chain FA (**LCFA**), 30% NDF, and 17% CP (assayed values, methods described below). After the preliminary period and washout period, cows were abruptly changed to 1 of 3 treatment regimens (Figure 1). The control treatment was a consistent day-to-day diet (Table 1) that was formulated to contain 5.9% LCFA. Cows on the second treatment (moderate variation treatment) were fed a diet with 6.4% LCFA for a 4-d phase, then abruptly changed to a diet with 5.4% LCFA for a 4-d phase, then 6.4% for 4 d, and then 5.4% for 4 d (i.e., two 4-d phases within two 8-d cycles). Cows on the third treatment (high variation treatment) followed the same schedule as cows on the moderate variation treatment except that the diet contained either 7.0 or 4.8% LCFA (Figure 1). Over the 16-d period, the average concentrations of LCFA in the diets were the same for all treatments. Two concentrate mixes (one with no added corn oil and one with 4.1% added corn oil) were made at the feed mill, and daily TMR were made at the dairy center by using different ratios of those 2 concentrate mixes. Cows were housed in tie stalls, fed once daily for ad libitum consumption

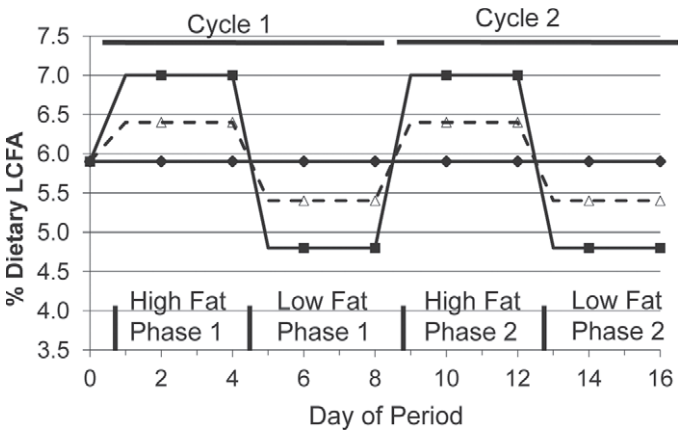

Figure 1. Treatment and milk sampling schedule. The control diet was 5.9% long-chain FA (LCFA) over the 16-d period (solid line, diamonds). The moderate variation treatment had diets with 6.4 or 5.4% LCFA fed in 4-d phases (dashed line, triangles). The high variation treatment had diets with 7.0 or 4.8% LCFA (solid line, squares). The days with a marker indicate when milk (morning and evening) was sampled. After this 16-d period was finished, cows were fed a preliminary diet for 12 d and then assigned to new treatments, and the schedule was repeated.

(amount of DM offered daily averaged 108% of DMI), and milked twice daily. Cows were weighed approximately 2 h after feeding on the first and last day of each period, and average BW were 589 ± 40 kg for first-parity cows and 652 ± 45 kg for multiparous cows.

The control diet was formulated to mimic a diet with a 25% inclusion rate of distillers grains that contained 11.2% fat (mean fat concentration from 49 samples of distillers grains from across the United States compiled in March 2009; University of Minnesota, 2009). The standard deviation for fat concentration in that data set was 1.6%. The moderate variation treatment represents the mean fat concentration for distillers grains ± 1.2 standard deviation units (i.e., 75% of the population should be within ±1.2 SD units). The high variation treatment represents the mean fat concentration of distillers grains ± 3 standard deviation units (i.e., 99% of the population). An infinite number of dietary treatment patterns are possible, but we chose to use 4-d phases to mimic a farm receiving a new shipment of distillers grains every 4 d (i.e., a 750-cow dairy farm feeding a diet with 25% distiller grains would require a 20-tonne load approximately every 4 d). A consistent pattern of high, low, high, low fat concentration is unlikely to occur; however, this was chosen because it simplified the experimental protocol and because it represents a worst-case scenario (abrupt change from very low to very high fat concentrations). If this amount of variation does not influence cows, then it is unlikely that less (more realistic) variation would influence cows.