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Effects of short-term variation in forage quality and forage to concentrate ratio on lactating dairy cows

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ABSTRACT

Within-farm variation in forage composition can be substantial and potentially costly, and it presents challenges for sampling the forage accurately. We hypothesized that day-to-day variation in forage neutral detergent fiber (FNDF) concentrations and diet variation caused by sampling error would have negative effects on production measures in lactating dairy cows. Twenty-four Holstein cows (73 d in milk) were used in 8 replicated 3 × 3 Latin squares with 21-d periods. Treatments were (1) control (CON), (2) variable (VAR), and (3) overreacting (ORR). On average, over the 21-d period, all 3 treatments were the same [24.7% FNDF and 48.2% forage dry matter (DM) composed of 67% alfalfa silage and 33% grass silage]. The CON treatment was essentially consistent day-to-day in total forage and FNDF concentrations and proportion of alfalfa and grass silages. The VAR treatment changed daily (in a random pattern) in proportion of alfalfa and grass silages fed, which resulted in day-to-day changes in FNDF (range was 21.5 to 28%). The ORR treatment varied in a 5-d cyclic pattern in total forage and FNDF concentrations (26, 24, 28, and 21.5% FNDF). Over the 21 d, ORR (25.1 kg/d) had higher DM intake compared with CON (24.5 kg/d) and VAR (24.3 kg/d). Milk production (42.8 kg/d), milk fat (3.5%), and milk protein (2.8%) were not affected by treatment; however, a treatment × day interaction was observed for milk production. Lower daily milk yields for VAR and ORR compared with CON were rare; they only followed sustained 4- and 5-d periods of feeding higher FNDF diets compared with CON. In contrast, increased daily milk yields for VAR and ORR versus CON were more frequent and followed sustained diet changes of only 2 or 3 d. Lipolytic and lipogenic-related enzyme mRNA abundances in subcutaneous adipose tissue were not affected by treatment. Treatment × day interactions were observed for milk fatty acid markers of cellulolytic bacteria (*iso*-14:0, *iso*-15:0, *iso*-16:0) and lipolysis (18:0) and generally followed the expected response to changes in daily rations. Overall, extreme daily fluctuations in FNDF had no cumulative negative effect on production measures over a 21-d period, and daily responses to transient increases in FNDF were less than expected.

Key words: variation, forage neutral detergent fiber, milk fatty acid

INTRODUCTION

Within-farm variation in nutrient composition of forages can be substantial. On 8 commercial dairy farms over a 14-d sampling period, the average within-farm, day-to-day standard deviation and range for hay crop silage NDF were 2.4% and 8.5 percentage units, respectively (Weiss et al., 2012). Because forages usually have high dietary inclusion rates for lactating cows, the variation in forage composition could lead to substantial day-to-day variation in the composition of the TMR.

In high-producing dairy cows limited by physical fill, greater concentrations of forage NDF (**FNDF**) decrease DMI, NE_L intake, and milk production (Allen, 2000). Reduced concentrations of FNDF result in the opposite response: increased DMI and milk production when effective fiber is adequate and starch concentrations are not excessive (Allen, 2000). However, these responses are usually measured in experiments lasting weeks. What is not known is the effect of short-term (i.e., daily) changes in diet FNDF and whether daily variation has cumulative effects on cows. Oscillating concentrations of dietary long-chain fatty acids reduced DMI and milk production but the response did not occur until cows were on treatment for about 8 d (Weiss et al., 2013). In contrast, oscillation of dietary CP had no negative short-term or cumulative negative effects on nutrient utilization or growth in beef cattle (Cole et al., 2003). The effects of day-to-day variation in concentrations of NDF or in forage quality on dairy cows are not known.

Another diet formulation issue related to feed variation is sampling. Obtaining a representative sample and determining, in a timely manner, whether the nutrient composition of a feed has indeed changed is

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difficult when the feed is highly variable (St-Pierre and Cobanov, 2007). A common approach to formulation is to use data from the most recent sample without considering potential sampling and analytical errors and without consideration of previous data from that feed. The new sample is treated as if it represents a new population, thus resulting in reformulation of the diet using the new data. This can result in overreaction (i.e., changing the diet formulation when the ingredient composition actually did not change), causing the TMR to vary in a pattern reflecting diet reformulation.

Based on field observations, day-to-day variation in diet composition is thought to be detrimental to milk production and farm profitability (Barmore and Bethard, 2005). We hypothesized that substantial day-to-day variation in diet FNDF would (1) decrease DMI and milk production and (2) affect partitioning of nutrients in mid-lactation dairy cows. We also hypothesized that variation imposed by diet reformulation in response to unrepresentative samples would have similar negative effects.

MATERIALS AND METHODS

All procedures involving animals were approved by The Ohio State University Institutional Animal Care and Use Committee. Twenty-four Holstein cows were blocked into groups of 3 by parity (2 blocks of primiparous and 6 blocks of multiparous) and milk production (multiparous cows only) and randomly assigned to 1 of 3 treatment sequences in 8 orthogonally replicated 3 × 3 Latin squares. Four squares started the experiment together (group 1) and a second group of 4 squares started the experiment 21 d later (group 2). Period length was 21 d and the entire experiment was completed in 84 d. All cows were moved into a tiestall barn and fed the control diet for 7 d before starting the experiment. At the beginning of the experiment, BW and DIM averaged 645 kg (SD = 64 kg) and 73 d (SD = 11 d). Cows were housed in individual tiestalls, fed once daily for ad libitum consumption, and milked twice daily (0200 and 1300 h); milk weights were recorded. Diets were fed as a TMR at approximately 0300 h for a target of 5% refusals. Actual refusals averaged 4.1% across all cows and days. Cows were weighed on 2 consecutive days before the experiment and on the last 2 d of each period. Cows were body condition scored (1 = emaciated; 5 = obese) by 3 independent people (scores averaged within cow-period) at the beginning of the experiment and on d 21 of each period.

Treatments were control (**CON**), variable (**VAR**), and overreacting (**ORR**). On average, all diets were identical in nutrient concentrations to CON over the 21-d periods. The average diet (CON) was formulated using NRC (2001) for 41 kg of NE_L-allowable milk and 45 kg of MP-allowable milk with 9.8% RDP and 6.9% RUP. The CON diet contained 2 different alfalfa silages: a grass silage and a corn grain-based concentrate mix (Tables 1 and 2). The grass silage was composed mostly of mature orchardgrass (Table 3). Two independent alfalfa silages stored in separate Harvestore silos (Engineered Storage Products Company, DeKalb, IL) were used to reduce the variation in alfalfa silage composition (Table 3). Altering the proportion of alfalfa to grass silage was used to produce the desired day-to-day changes in diet forage composition and FNDF concentrations.

The CON diet was formulated to have a constant 24.7% FNDF from day to day with essentially constant alfalfa:grass and forage:concentrate ratios (Table 1, Figure 1). The VAR diet was designed to be variable in FNDF concentration from day to day but to average 24.7% FNDF over 21 d (Table 2, Figure 2). The FNDF concentration was varied by changing the proportion of alfalfa and grass silage, but the forage to concentrate ratio was held constant. Daily inclusion rates of alfalfa and grass silages were determined randomly via Monte Carlo uniform distribution simulation before the experiment, and the resulting daily FNDF concentration pattern was repeated each period. The variance used in the simulation was based on variation in silage NDF concentrations measured on commercial dairy farms (Weiss et al., 2012).

Over each 21-d period, the forage to concentrate ratio for ORR changed 4 times, but on average the diet was 24.9% FNDF and had the same forage to concentrate ratio as CON. The ratio of grass to alfalfa was held constant for ORR (Table 1, Figure 1). The ORR mimicked variation that could be caused by using data from unrepresentative samples (i.e., a change in NDF was observed but the silage NDF did not really change). The diet was reformulated using the hypothetically erroneous silage NDF sample results with the goal of maintaining a constant FNDF. Because the silage NDF really did not change, actual FNDF concentrations changed instead. On d 1 to d 5, the forage percentage of the ORR diet was higher than that of CON and represented formulating a diet with a lower than actual NDF silage sample result. On d 6 to 10, the forage percentage of the ORR diet was lower than that of CON and represented formulating with a higher than actual NDF silage sample. On d 11 to 15 and d 16 to 20, a lower than actual and a higher than actual NDF sample result, respectively, were used, which resulted in a higher and lower forage percentage of the formulated diet compared with CON.