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Long-term palmitic acid supplementation interacts with parity in lactating dairy cows: Production responses, nutrient digestibility, and energy partitioning

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ABSTRACT

The objective of our study was to evaluate the effects of long-term palmitic acid (C16:0) supplementation and parity on production, nutrient digestibility, and energy partitioning of mid-lactation dairy cows. Forty mid-lactation Holstein cows (18 primiparous and 22 multiparous) were used in a block design. Cows were assigned to receive either a control diet containing no supplemental fat (CON) or a C16:0-enriched supplemented diet (PA; 1.5% diet dry matter) fed for 10 wk. Compared with CON, PA increased dry matter intake, milk yield, cumulative milk yield, milk fat content, milk fat yield, 16-carbon milk fatty acid (FA) yield, 3.5% fat-corrected milk yield, and energy-corrected milk yield. Additionally, PA increased body weight change, but did not affect body condition score change compared with CON. A tendency for a treatment by parity interaction was observed for milk yield due to PA increasing milk yield in multiparous but not in primiparous cows. In addition, we observed interactions between treatment and parity for fat-corrected milk, energy-corrected milk, and milk fat yield due to PA increasing these variables to a greater extent in multiparous compared with primiparous cows. Interestingly, we observed an interaction between treatment and parity for body weight change, due to PA increasing body weight change in primiparous but not in multiparous cows. The PA treatment increased dry matter and neutral detergent fiber digestibilities compared with CON. Although PA did not affect 18-carbon FA digestibility, compared with CON, PA decreased 16-carbon and total FA digestibilities and increased total FA intake by 470 g/d and absorbed total FA by 316 g/d. We also observed an interaction between treatment and parity for total absorbed FA due to PA increasing it to a greater extent in multiparous than in primiparous cows. Compared with CON, PA increased apparent energy intake and milk energy output. We observed an interaction between treatment and parity for milk energy output due to PA increasing milk energy output to a greater extent in multiparous than primiparous cows. Additionally, an interaction between treatment and parity was observed for energy output in body reserves due to PA increasing energy output in body reserves in primiparous but not in multiparous cows. In conclusion, production responses of dairy cows to PA were consistent throughout the 10-wk treatment period. In addition, PA supplementation interacted with parity, with production responses increased to a greater extent in multiparous than primiparous cows and energy partitioned to body reserves only increased in primiparous cows.
Key words: palmitic acid, milk fat, digestibility, partitioning

INTRODUCTION

Fat supplements are commonly added to dairy cow diets to increase dietary energy density, feed efficiency, the yields of milk and milk fat, and to improve energy balance (Palmquist, 1994; Rabiee et al., 2012). Recently, considerable research has focused on palmitic acid (**C16:0**) because of its potential to increase milk fat concentration and yield, and the efficiency of milk production compared with a control diet (Lock et al., 2013; de Souza et al., 2018) and with other FA supplements (Rico et al., 2014a,b). However, our research, and work by others, has been conducted mostly in changeover design experiments (i.e., crossover and Latin squares) with production and metabolic responses evaluated during short-term feeding (maximum of 21-d feeding periods). This raises a question about the consistency of the response under long-term conditions. Recently, Mathews et al. (2016) observed that long-term feeding (7 wk) of mid-lactation cows with C16:0 (3.9% of diet DM) increased the yield of milk and milk components without suppressing DMI, relative to no added fat supplementation. Considering that most dairy farms that use supplemental fat would include it in diets within the range of 0.5 to 2.5% of ration DM (Rico et

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al., 2017), the determination of long-term C16:0 feeding within this range has important implications.

Variation in response to C16:0 supplementation has also been reported. Previous studies have observed that C16:0 supplementation decreased DMI (Lock et al., 2013; Rico et al., 2014a), increased DMI (Mosley et al., 2007), or did not affect DMI (Piantoni et al., 2013; de Souza et al., 2017b, 2018) compared with a control diet. Additionally, milk yield responses have also varied with some studies reporting no effect of C16:0 on milk yield (Lock et al., 2013; Rico et al., 2014a), whereas others observed increases in milk yield (Mosley et al., 2007; Piantoni et al., 2013). The observed variations when using a C16:0-enriched supplement suggest that other dietary or animal factors interact with fatty acid (**FA**) supplementation in altering dairy cow responses. One possible animal factor that may interact with fat supplementation is parity, but results have been inconsistent (Holter et al., 1992; Drackley et al., 2003). Holter et al. (1992) observed that milk yield increased in primiparous but not in multiparous cows when Ca-salts of palm FA were fed for 16 wk. Conversely, Drackley et al. (2003) did not observe interactions between parity and white grease supplementation (3% diet DM) on production responses of mid-lactation cows. The differences in milk yield response and energy partitioning in primiparous compared with multiparous cows to supplemental fat may be due to primiparous cows having additional energy requirements for growth as well as for milk production (Grummer et al., 1995). To our knowledge, no reports in the current literature have evaluated whether primiparous and multiparous cows would respond differently to C16:0 supplementation.

Therefore, the objective of our study was to evaluate the effects of long-term C16:0 supplementation and parity on yield of milk and milk components, and nutrient digestibility of mid-lactation dairy cows. We hypothesized that long-term feeding of a C16:0-enriched supplement would consistently increase production responses of mid-lactation cows. Also, we postulated that production responses of multiparous cows would be greater than primiparous cows due to primiparous cows having additional energy requirements for growth.

MATERIALS AND METHODS

Design and Treatment Diets

Experimental procedures were approved by the Institutional Animal Care and Use Committee at Michigan State University. Forty mid-lactation Holstein cows, 18 primiparous and 22 multiparous, averaging (mean ± SD) 136 ± 45 and 144 ± 44 DIM, 41.5 ± 4.9 and 52.1 ± 5.9 kg of milk, and 3.19 ± 0.21 and 3.02 ± 0.25 BCS, respectively, from the Michigan State University Dairy Field Laboratory were used in a complete randomized block design. All animals received a common diet with no fat supplementation during a 14-d preliminary period to obtain baseline values. Cows were blocked by parity (primiparous vs. multiparous) milk yield (up to 1.2 kg difference) and BCS (up to 0.5-unit difference). Cows received either a control diet containing no supplemental fat (**CON**) or a C16:0-enriched supplemented diet (**PA**; 1.5% diet DM;) fed for 10 wk. The PA supplement was a free FA product of high purity, contained approximately 81% C16:0 and 97% total FA, and replaced soyhulls in the diet. Diets were formulated to meet the requirements of the average cow in the group (NRC, 2001; Table 1). After the supplementation period, all cows received the CON diet for 2 wk to evaluate carryover effects. Dry matter concentration of forages was determined twice weekly and diets were adjusted when necessary. Throughout the experiment cows were housed in individual tie stalls. Access to feed was blocked daily from 1000 to 1200 h to allow for the collection of orts and offering feed. Cows were fed 115% of expected intake daily, and feed intake was recorded. Water was available ad libitum in each stall and stalls were bedded with sawdust and cleaned twice per day.

Data and Sample Collection

Milk yield and feed offered and refused were recorded daily throughout the experiment and averaged by week for further analysis. Samples of all diet ingredients (0.5 kg) and orts from each cow (~12.5%) were collected weekly during the entire experiment and stored in plastic bags at −20°C until processing. On d 63 (wk 9), fecal samples (500 g) were collected every 6 h, representing every 6 h of a 24-h period to account for diurnal variation, for nutrient digestibility analysis. Feces were stored in a sealed plastic cup at −20°C until dried. Blood samples (~15 mL) were collected by venipuncture of coccygeal vessels within 1 h before feeding on d 21, 42, and 63 of the study and stored on ice until centrifugation at 2,000 × g for 15 min at 4°C (within 30 min of sample collection). Plasma was transferred into microcentrifuge tubes and stored at −20°C. Throughout the experiment, milk samples were collected twice a week at each milking and stored with preservative at 4°C for component analysis (Universal Lab Services, East Lansing, MI). An additional milk sample was collected at each milking on d 21, 42, and 63 of the study and stored without preservative at −20°C for determination of FA profile. Body weight measurements were taken 3 times per week following the afternoon milking,