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Short communication: Comparison of a palmitic acid-enriched triglyceride supplement and calcium salts of palm fatty acids supplement on production responses of dairy cows

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ABSTRACT

The objective of our study was to evaluate the effects of feeding a palmitic acid-enriched triglyceride supplement or a calcium salts of palm fatty acid (FA) supplement on nutrient digestibility and production responses of mid-lactation dairy cows. Fifteen Holstein cows (139 ± 39 d in milk) were randomly assigned to treatment sequence in a 3 × 3 Latin square design. Treatments were a control diet (CON; no fat supplement) and 1.5% of FA added either as a palmitic acid-enriched triglyceride supplement (PA-TG) or as calcium salts of palm FA supplement (Ca-FA). Fat-supplemented treatments did not affect dry matter intake (DMI) compared with CON, but Ca-FA reduced DMI compared with PA-TG. Compared with CON, fat-supplemented treatments increased 18-carbon FA digestibility by 2.0 percentage units but did not affect digestibility of total FA or 16-carbon FA. Compared with Ca-FA, PA-TG reduced total FA digestibility by 8.7 percentage units due to a decrease in 16-carbon FA digestibility (21.7 percentage units). Both fat supplements increased neutral detergent fiber (NDF) digestibility compared with CON (3.90 percentage units), and PA-TG tended to increase NDF digestibility by 1.60 percentage units compared with Ca-FA. Compared with CON, fat-supplemented treatments increased milk yield (1.05 kg/d), 3.5% fat-corrected milk yield (2.20 kg/d), and energy-corrected milk yield (1.80 kg/d). Also, PA-TG increased milk fat yield (50 g/d) and milk energy output (1.0 Mcal/d) and tended to increase milk fat content (0.07 percentage units) and energy-corrected milk yield (1.0 kg/d) compared with Ca-FA. Fat-supplemented treatments reduced the yield of de novo milk FA (23 g/d) and increased the yields of mixed (43 g/d) and preformed (52 g/d) milk FA compared with CON. The PA-TG treatment increased the yield of 16-carbon (66 g/d) milk FA compared with Ca-FA, whereas Ca-FA increased the yield of preformed (60 g/d) milk FA. Fat-supplemented treatments increased intake of net energy for lactation by 1.80 Mcal/d, milk energy output by 1.30 Mcal/d, and energy in body reserves by 0.30 Mcal/d compared with CON. The Ca-FA treatment increased energy allocated to body reserves (0.60 Mcal/d), energy partitioning toward body reserves (1.20 percentage units), and body condition score change (0.06 units), and tended to increase body weight change (0.16 kg/d) and body condition score (0.08 units) compared with PA-TG. In conclusion, feeding a palmitic acid-enriched triglyceride supplement increased milk energy output due to increased yields of milk and milk fat, whereas feeding a calcium salts of palm FA supplement increased FA digestibility and energy partitioned to body reserves.
Key words: palmitic acid, triglyceride, fatty acid, production, calcium salts of palm fatty acid

Short Communication

Fat supplements are commonly added to dairy cow diets to increase dietary energy density, feed efficiency, and yields of milk and milk fat, and to improve energy balance (Palmquist, 1994; Rabiee et al., 2012). One of the most common sources of rumen-protected fat is calcium salts, conceived over 30 yr ago to minimize the negative effects of UFA on ruminal populations, especially on cellulolytic bacteria (Palmquist, 1991). Individual fatty acids (**FA**) can have different effects and considerable recent research has focused on palmitic acid (C16:0) supplementation. Palmitic acid has been reported to increase milk fat concentration and yield and the efficiency of milk production compared with non-fat-supplemented diets (Lock et al., 2013; de Souza et al., 2017) and with other fat supplements (Rico et al., 2014a,b). However, with the exception of Weiss et al. (2011), published studies in lactating dairy cows have evaluated the effect of palmitic acid-enriched free FA supplements rather than triglyceride (**TG**) supplements.

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Changes in intake and nutrient digestibility due to supplemental fat may affect, positively or negatively, digestible energy available for milk production, body reserves, or both (Boerman et al., 2015a). Weiss et al. (2011) observed lower total FA digestibility for a palmitic acid-enriched TG supplement compared with a nonfat control diet when fed at 3% of diet DM. However, the decrease in FA digestibility was smaller than that previously reported in other studies that fed saturated TG supplements, in which total FA digestibility ranged from 33 to 62% (e.g., Pantoja et al., 1995; Elliott et al., 1999; Weiss and Wyatt, 2004). Although these results suggest that a TG supplement with a low proportion of C18:0 (and high proportions of C16:0 and C18:1) has moderate digestibility (Weiss et al., 2011), comparative data for feeding palmitic acid-enriched TG supplements to lactating dairy cows are not available. Importantly, considering that most dairy farms that use supplemental fat would include it in diets within a range of 0.5 to 2.0% of ration DM, determining the effects of a palmitic acid-enriched TG supplement within this range has important applications. Therefore, characterizing the effects of feeding a palmitic acid-enriched TG supplement under typical feeding conditions is of particular importance.

The objective of the current experiment was to characterize the effects of feeding a palmitic acid-enriched TG supplement on nutrient digestibility and production responses of mid-lactation dairy cows compared with a nonfat control and the well-investigated supplement, calcium salts of palm FA. We hypothesized that the calcium salts of palm FA supplement would have higher digestibility than the TG supplement but that the differences would be smaller than previously reported in the literature due to differences in the FA profile of the TG supplement. Additionally, we postulated that the TG supplement would increase milk FA yield to a greater extent than the calcium salts of palm FA supplement due to differences in the FA profile of the supplemental fats.

Experimental procedures were approved by the Institutional Animal Care and Use Committee at Michigan State University (East Lansing). Fifteen mid-lactation Holstein cows at the Michigan State University Dairy Field Laboratory were randomly assigned to treatment sequence in replicated 3 × 3 Latin squares with 21-d periods. All animals received a common diet with no supplemental fat during a 14-d preliminary period to obtain baseline values. At the beginning of the trial, mean (±SD) DIM, BW, and milk yield were 139 ± 39 d, 690 ± 44 kg, and 51.4 ± 4.5 kg/d, respectively.

Treatments were a control diet (**CON**; no supplemental fat) and 1.5% of FA added either as a palmitic acid-enriched TG supplement (**PA-TG**) or as calcium salts of palm FA supplement (**Ca-FA**). The fat supplements replaced soyhulls in the diets (Table 1). Both fat-supplemented diets were balanced for glycerol concentration; glycerol was not added to the CON treatment. Although it is important to consider possible different metabolic fates for the glycerol fed in the diet and that released from TG in the intestine, it is unlikely that it affected our results due to the very small amount required to balance glycerol intake between PA-TG and Ca-FA. The DM concentration of forages was determined twice weekly, and diets were adjusted when necessary. Cows were housed in tie-stalls throughout the entire experiment and milked twice daily (0400 and 1500 h). Access to feed was blocked from 0800 to 1000 h for collection of orts and offering of new feed. Cows were fed 115% of expected intake at 1000 h daily. Water was available ad libitum in each stall and stalls were bedded with sawdust and cleaned twice daily.

Samples and data for production and digestibility variables were collected during the last 5 d of each treatment period (d 17 to 21). Feed ingredients and orts were collected daily and composited by period and analyzed for DM, NDF, CP, starch, and FA contents as described by Boerman and Lock (2014). Fecal (500 g) samples were collected every 15 h, resulting in 8 samples per cow per period, and nutrient digestibility was calculated using indigestible NDF (iNDF) as an internal marker as previously described (Piantoni et al., 2013). Fat supplements were composited by period and chemical composition and particle size distribution determined (de Souza et al., 2017; Supplemental Table S1; https://doi.org/10.3168/jds.2017-13560). Individual milk samples were analyzed for fat, true protein, and lactose by mid-infrared spectroscopy (AOAC, 1990; method 972.160), and for FA using GLC (Lock et al., 2013). Yields of 3.5% FCM, ECM, and milk components were calculated using milk yield and component concentrations for each milking, summed for a daily total, and averaged for each collection period. Body weight was measured 3 times per week, and 4 trained investigators determined BCS on a 5-point scale in 0.25-point increments on the last day of each period (Wildman et al., 1982). We determined energy partitioning using the procedures described by Boerman et al. (2015b). Data were used to calculate milk energy output and body tissue gain throughout each treatment period. Milk energy output (Mcal/d) was calculated according to NRC (2001): milk energy output (Mcal/d) = [9.29 × fat (kg) + 5.63 × true protein (kg) + 3.95 × lactose (kg)], where each component was based on the average output of a cow during the 5-d sampling period. Mean daily BW change (ΔBW, kg/d) was calculated for each cow within period by linear regression after 2 iterations of removing outliers. Energy partitioned to body tis-