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Short communication: Lactational responses to palmitic acid supplementation when replacing soyhulls or dry ground corn

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ABSTRACT

The objective of this study was to evaluate the response of mid-lactation dairy cows to a palmitic acid (C16:0)-enriched fatty acid supplement when replacing soyhulls or dry ground corn in the diet. Twenty-four multiparous Holstein cows (182 ± 60 d in milk; mean ± SD) were blocked by preliminary 3.5% fat-corrected milk and randomly assigned to treatment sequence in a replicated 3 × 3 Latin square design with 21-d periods. Treatments consisted of a control diet containing no supplemental fat (CON), and 2 C16:0-enriched fatty acid-supplemented treatments (PA; BergaFat F100, Berg & Schmidt, Hanover, Germany) as a replacement for either soyhulls (PA-SH) or dry ground corn (PA-CG). The C16:0-enriched supplement was fed at 1.5% of diet dry matter. The PA treatments did not affect dry matter intake, but PA-SH increased dry matter intake by 1.4 kg/d compared with PA-CG. The PA treatments did not affect milk yield; however, PA-SH increased milk yield by 2.4 kg/d compared with PA-CG. The PA treatments tended to decrease milk protein content (3.12 vs. 3.15%). In contrast, PA-SH increased milk protein content (3.14 vs. 3.10%) and milk protein yield (1.27 vs. 1.19 kg/d) compared with PA-CG. The PA treatments increased milk fat concentration (3.68 vs. 3.55%) and milk fat yield (1.46 vs. 1.38 kg/d). The increase in milk fat yield with PA treatments was due to the increase in the yield of 16-carbon fatty acid in milk fat. Furthermore, PA-SH tended to increase yield of de novo fatty acids and yield of 16-carbon fatty acids compared with PA-CG. The PA treatments tended to increase feed efficiency (3.5% fat-corrected milk/dry matter intake) compared with CON (1.51 vs. 1.46). The PA-SH treatment tended to increase insulin concentration compared with PA-CG (1.58 vs. 1.49 μg/L) and PA treatments increased nonesterified fatty acids compared with CON (110 vs. 99 μEq/L). Overall, PA treatments improved feed efficiency and increased milk fat yield and the response to the C16:0-enriched fatty acid supplement was greater when it replaced soyhulls compared with when it replaced dry ground corn in the diet.
Key words: fat supplementation, feed efficiency, milk fat, palmitic acid

Short Communication

Fat supplements are commonly added to the dairy cow diet to increase dietary energy density, feed efficiency, the yields of milk and milk fat, and improve energy balance (Palmquist, 1994; Rabiee et al., 2012); however, production responses to sources of fats vary greatly (Rabiee et al., 2012). Individual fatty acids can have different effects and recently considerable research has focused on palmitic acid (C16:0) supplementation. This fatty acid has been reported to increase milk yield, milk fat concentration and yield, and the efficiency of milk production (Mosley et al., 2007; Lock et al., 2013; Piantoni et al., 2013); however, variation in response to C16:0 supplementation has been reported. Previous studies have reported 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) compared with a control diet. Additionally, milk yield responses also vary greatly, and some studies reported no effect of C16:0 on milk yield (Lock et al., 2013; Rico et al., 2014a), or increases in milk yield when it was supplemented (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 supplementation in altering dairy cows responses.

Based on the aforementioned results, we hypothesized that responses to C16:0 supplementation would differ depending on if the supplement replaced a source of glucose precursors, such as dry ground corn, or a fermentable fiber source, such as soyhulls. Therefore, the objective of our study was to evaluate the response of mid-lactation dairy cows to C16:0 supplementation when replacing soyhulls or dry ground corn in the diet.

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Experimental procedures were approved by the Animal Care and Use Committee of Michigan State University. Twenty-four mid-lactation multiparous Holstein cows at the Michigan State University Dairy Field Laboratory (East Lansing) were used in a replicated 3 × 3 Latin squares balanced for carryover effects with 21-d periods. At the beginning of the first experimental period mean DIM, BW, and milk yield (mean ± SD) were 182 ± 60 d, 746 ± 63 kg, and 46.9 ± 8.5 kg/d, respectively. Cows were blocked by preliminary 3.5% FCM and randomly assigned to treatments.

Treatments consisted of a control diet containing no supplemental fat (**CON**) and 2 C16:0-enriched fatty acid-supplemented treatments (**PA**; BergaFat F100, Berg & Schmidt, Hanover, Germany) either as a replacement for soyhulls (**PA-SH**) or dry ground corn (**PA-CG**). The C16:0-enriched supplement was fed at 1.5% of diet DM and contained 91 g/100 g FA of C16:0. Ingredients and nutrient composition of diets fed as a TMR are described in Table 1. Diets were formulated to meet the requirements of the average cow in the group according to NRC (2001). Cows were housed in tiestalls throughout the entire experiment and milked twice daily (0500 and 1600 h). Cows were fed 115% of expected intake and access to feed was blocked from 1000 to 1200 h for collection of orts and offering of new feed. Water was available ad libitum in each stall.

Samples and data for production variables were collected during the last 5 d of each treatment period (d 17–21). Samples of all diet ingredients (0.5 kg) were collected daily and composited by period and analyzed for NDF, CP, starch, and fatty acid concentrations as described by Piantoni et al. (2013). Individual milk samples were analyzed for fat, true protein, and lactose concentration by mid-infrared spectroscopy (AOAC, 1990; method 972.160). A second milk sample was collected and composited by period based on milk fat yield and analyzed for fatty acids using GLC according to Lock et al., (2013). Yields of 3.5% FCM, milk energy, and milk components were calculated using milk yield and component concentrations averaged for each period (d 17–21).

Blood samples were collected every 15 h and composited by period and analyzed for glucose, insulin, and nonesterified fatty acids (**NEFA**) as previously described by Boerman et al. (2015). Body weight was recorded on the last 2 d (d 20 and 21) of each period. Three trained investigators determined BCS on a 5-point scale with 0.25-point increments according to Wildman et al. (1982) on the last day of the preliminary period and each treatment period.

Data were analyzed using the MIXED procedure of SAS (version 9.2; SAS Institute Inc., Cary, NC). The statistical model included the fixed effect of treatments and period, preliminary 3.5% FCM as covariate, the interaction between treatment and preliminary 3.5% FCM, and the random effect of cow. The interaction between period and treatment was initially included in the model and removed because $P > 0.20$ for all variables. Two preplanned contrasts were used to evaluate (1) the effect of PA treatments [CON vs. PA; 1/2 (PA-SH + PA-CG)], and (2) the effect of PA replacing either soyhulls or dry ground corn in the diet (PA-SH vs. PA-CG). Contrasts were declared significant at $P \leq 0.05$ and trends at $0.05 < P \leq 0.10$.

The content of CP and forage NDF were similar across the diets (Table 1). As expected, NDF and starch content were lower for PA-SH and PA-CG, respectively. Total dietary fatty acids were 2.8, 4.2, and 4.1% for CON, PA-SH, and PA-CG, respectively. The intake of C14:0, C16:0, C18:0, and *cis*-9 C18:1 increased with PA treatments compared with CON ($P = 0.01$;

Table 1. Ingredient and nutrient composition of the treatment diets

	Treatment[1]		
Item	CON	PA-SH	PA-CG
Ingredient, % of DM			
Corn silage	31.4	31.4	31.4
Alfalfa silage	11.1	11.1	11.1
Wheat straw	2.1	2.1	2.1
Dry ground corn	13.4	13.4	11.9
High-moisture corn	13.7	13.7	13.7
Soybean meal	14.9	14.9	14.9
Whole cottonseed	7.4	7.4	7.4
Soyhulls	2.6	1.1	2.6
Vitamin-mineral mix[2]	2.0	2.0	2.0
Limestone	0.64	0.64	0.64
Sodium bicarbonate	0.73	0.73	0.73
C16:0-enriched fatty acid supplement[3]	0.0	1.53	1.53
Nutrient composition, % of DM			
DM[4]	53.4	53.4	53.4
NDF	29.0	28.0	28.8
CP	16.8	16.7	16.7
Starch	28.1	28.1	27.1
Fatty acids	2.76	4.15	4.12
16:0	0.49	1.77	1.77
18:0	0.07	0.09	0.09
cis-9 18:1	0.53	0.59	0.58
cis-9,*cis*-12 18:2	1.43	1.43	1.41
cis-9,*cis*-12,*cis*-15 18:3	0.13	0.13	0.13

[1]CON = control diet; PA-SH = 1.5% of C16:0-enriched fatty acid supplement replacing soyhulls; PA-CG = 1.5% of C16:0-enriched fatty acids supplement replacing ground corn.

[2]Vitamin and mineral mix contained 34.1% dry ground shelled corn, 25.6% white salt, 21.8% calcium carbonate, 9.1% Biofos (The Mosaic Co., Plymouth, MN), 3.9% magnesium oxide, 2% soybean oil, and <1% of each of the following: manganese sulfate, zinc sulfate, ferrous sulfate, copper sulfate, iodine, cobalt carbonate, vitamin E, vitamin A, vitamin D, and selenium.

[3]C16:0-enriched fatty acid supplement (BergaFat F100, Berg & Schmidt, Germany). The supplement contained (g/100 g of fatty acid) 1.2 of C14:0, 91.1 of C16:0, 1.7 of C18:0, 4.9 of *cis*-9 C18:1, and 99.0% of total fatty acids.

[4]Expressed as percent of as fed.