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Comparison of enriched palmitic acid and calcium salts of palm fatty acids distillate fat supplements on milk production and metabolic profiles of high-producing dairy cows

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ABSTRACT

A variable response to fat supplementation has been reported in dairy cows, which may be due to cow production level, environmental conditions, or diet characteristics. In the present experiment, the effect of a high palmitic acid supplement was investigated relative to a conventional Ca salts of palm fatty acids (Ca-FA) supplement in 16 high-producing Holstein cows (46.6 ± 12.4 kg of milk/d) arranged in a crossover design with 14-d periods. The experiment was conducted in a non-heat-stress season with 29.5% neutral detergent fiber diets. Treatments were (1) high palmitic acid (PA) supplement fed as free FA [1.9% of dry matter (DM); 84.8% C16:0] and (2) Ca-FA supplement (2.3% of DM; 47.7% C16:0, 35.9% C18:1, and 8.4% C18:2). The PA supplement tended to increase DM intake, and increased the yields of milk and energy-corrected milk. Additionally, PA increased the yields of milk fat, protein, and lactose, whereas milk concentrations of these components were not affected. The yields of milk de novo and 16-C FA were increased by PA compared with Ca-FA (7 and 20%, respectively), whereas the yield of preformed FA was higher in Ca-FA. A reduction in milk fat concentration of de novo and 16-C FA and a marginal elevation in *trans*-10 C18:1 in Ca-FA is indicative of altered ruminal biohydrogenation and increased risk of milk fat depression. No effect of treatment on plasma insulin was observed. A treatment by time interaction was detected for plasma nonesterified fatty acids (NEFA), which tended to be higher in Ca-FA than in PA before feeding. Overall, the palmitic acid supplement improved production performance in high-producing cows while posing a lower risk for milk fat depression compared with a supplement higher in unsaturated FA.

Key words: fat supplement, milk fat, palmitic acid

INTRODUCTION

High-energy-density diets are commonly fed to dairy cows to meet energy demands and reach the genetic potential for milk production, while maintaining health and reproductive efficiency. Increasing diet fermentability (e.g., high-concentrate, low-forage diets) increases diet energy density, but this approach can be detrimental to rumen function and milk fat yield. As an alternative, diet energy density can be enhanced by increasing fat concentration (Palmquist and Jenkins, 1980), which has been shown to increase milk yield, fat yield, and BCS in some cases (e.g., Weiss and Pinos-Rodriguez, 2009). Oilseeds, many plant by-products, and animal fats are common sources of fat in rations fed to dairy cows. However, they contain substantial levels of rapidly available PUFA, which can disrupt ruminal fermentation and fiber digestibility (Jenkins, 1993). As a result, research efforts have focused on increasing dietary fat while minimizing negative effects on rumen fermentation.

The responses to fat supplementation are highly variable, even within each fat type (Rabiee et al., 2012). A portion of the observed variation may be explained by stage of lactation, production level, DMI, and numerous dietary interactions [see review by Chilliard (1993)]. The FA profile of available FA supplements differs by level of unsaturation and chain length of saturated FA. Generally, high-SFA supplements are expected to have minimal effects on ruminal fermentation compared with higher PUFA supplements (Jenkins, 1993). Unsaturated FA are commonly supplemented as Ca salts to reduce the availability of the FA in the rumen, but protection from biohydrogenation (**BH**) is incomplete (~50%; Wu et al., 1991) and results in altered ruminal BH and milk fat depression (**MFD**) in some cases (Harvatine and Allen, 2006b; Rico et al., 2014).

An SFA supplement enriched in palmitic acid has recently garnered interest (Lock et al., 2013; Piantoni et al., 2013; Rico et al., 2014), as mammary extraction efficiency of palmitic acid is greater than that of stearic acid (Enjalbert et al., 2000). However, the response to enriched palmitic acid supplements also has been vari-

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able, with increased milk fat yield observed in some, but not all, experiments (see Rico et al., 2014). Additionally, we have previously reported interactions of fat supplement saturation and milk production level, where more unsaturated FA supplements fed as Ca salts resulted in MFD in high-, but not in low-producing cows (Harvatine and Allen, 2006a; Rico et al., 2014). The objective of the current experiment was to investigate the effect of an enriched palmitic acid supplement compared with a well-characterized Ca salts of palm FA (**Ca-FA**) supplement during a short-term feeding period (14 d). High-producing cows were selected and fed a lower-fiber diet (29.5% NDF) than our previous investigation (31%; Rico et al., 2014). We hypothesized that a high palmitic acid (**PA**) supplement would increase milk fat yield and pose a lower risk for MFD.

MATERIALS AND METHODS

Experimental Design and Treatments

The experiment was conducted from November to December 2010 in a tie-stall barn located at the Pennsylvania State University Dairy Production Research and Teaching Center (University Park). Sixteen multiparous high-producing Holstein cows (46.6 ± 12.4 kg of milk/d; 95 ± 27 DIM; 632 ± 49 kg of BW) were randomly assigned to 1 of 2 treatment sequences in a balanced crossover design. Experimental periods were 14 d in length. Treatments were (1) PA supplement (1.9% of DM; BergaFat F100; Berg + Schmidt GmbH & Co. KG, Hamburg, Germany) and (2) Ca-FA supplement (2.3% of DM; Megalac; Church & Dwight Co. Inc., Princeton, NJ). The PA supplement contained 84.8% C16:0 and 8.3% C18:1, and the Ca-FA supplement contained 47.4% C16:0, 35.9% C18:1, and 8.4% C18:2 (Supplemental Table S1; http://dx.doi.org/10.3168/jds.2013-7723). Both fat supplements were fed to provide approximately 2% of the ration DM as FA (Table 1). The PA diet included limestone to equalize Ca content of the Ca-FA supplement.

Cows were housed in a tie-stall barn and fed a TMR once per day (0800 h) at 110% of expected intake. Forage DM was determined weekly and diets adjusted accordingly. All cows received recombinant bST (Posilac; Elanco Animal Health, Greenfield, IN) every 14 d. Animal use procedures were approved by the Pennsylvania State University Institutional Animal Care and Use Committee.

Sampling and Analysis

Cows were milked twice per day at 0500 and 1700 h in a parlor and milk yield measured using an integrated milk meter [Afimilk (SAE Afikim), Kibbutz Afikim, Israel]. Milk was sampled at each milking from d 12 to 14 of each period. One subsample of each milking was stored at 4°C with a liquid preservative (Bronolab-WII; Advanced Instruments Inc., Norwood, MA) until analyzed for fat (filter B), protein, lactose, other solids, and MUN by infrared spectroscopy [MilkoScan 4000

Table 1. Ingredient and chemical composition of the experimental diets

Item	Diet[1] PA	Diet[1] Ca-FA
Ingredient, % of DM		
Corn silage[2]	37.1	37.1
Alfalfa haylage[3]	17.7	17.7
Canola meal	10.5	10.5
Ground corn	6.1	6.1
Rolled roasted soybeans	6.9	6.9
Cottonseed hulls	3.3	3.9
Bakery by-product[4]	6.4	6.4
Grass hay/straw[5]	4.2	4.2
Vitamin-mineral mix[6]	2.6	2.6
Sugar cane molasses	1.9	1.9
Ca-FA palm[7]	—	2.3
PA FA[8]	1.9	—
Ground limestone	0.9	—
NPN[9]	0.4	0.4
Nutrient, % of DM		
CP	16.9	17.0
NDF	29.3	29.7
ADF	18.1	18.4
Starch	24.3	24.3
Total FA[10]	7.0	7.1
C16:0	2.36	1.71
C18:1	1.37	1.92
C18:2	2.17	2.32

[1]PA = high palmitic acid supplement in free FA form; Ca-FA = Ca salts of palm FA.

[2]Contained 40.4% DM and 7.0% CP, 32.6% NDF, 18.3% ADF, and 42.0% starch on a DM basis.

[3]Contained 54.5% DM and 20.5% CP, 40.1% NDF, and 34.0% ADF on a DM basis.

[4]Cookie meal (Bakery Feeds Inc., Honey Brook, PA); contained 12.8% CP, 14% NDF, 49.7% starch, and 9.2% ether extract (DM basis).

[5]Contained 86.7% DM and 9.4% CP, 70.7% NDF, and 45.9% ADF on a DM basis.

[6]Contained (as-fed basis): 45.8% dried corn distillers grains with solubles, 35.8% limestone (38% Ca), 8.3% magnesium oxide (54% Mg), 6.4% salt, 1.73% vitamin ADE premix, 1.09% Se premix (0.06% Se), and 0.88% trace mineral mix. Composition (DM basis): 11% CP, 18% NDF, 5.2% fat, 14.9% Ca, 0.35% P, 4.58% Mg, 0.41% K; 0.31% S, 357 mg of Cu/kg, 1,085 mg of Zn/kg, 181 mg of Fe/kg, 6.67 mg of Se/kg, 125,875 IU of vitamin A/kg, 31,418 IU of vitamin D/kg, and 946 IU of vitamin E/kg.

[7]Calcium salts of palm FA (Megalac Church & Dwight Co. Inc., Princeton, NJ).

[8]High palmitic acid free FA (BergaFat F100, Berg + Schmidt GmbH & Co. KG, Hamburg, Germany).

[9]Nonprotein N fed as Optigen (Alltech Inc., Lexington, KY; 256% CP, DM basis).

[10]Complete FA profile in Supplemental Table S2 (http://dx.doi.org/10.3168/jds.2013-7723).