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Effect of source of supplemental fat in early lactation on productive performance and milk composition

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ABSTRACT

The objective of this research was to evaluate the effects of diets supplemented with rumen inert fat sources on early-lactation performance of dairy cows. Two studies were conducted that varied in total dietary fat level (3.4% of DM for study 1 and 5.1% of DM for study 2). Calcium salts of fatty acids (CSFA) rich in oleic acid versus SFA rich in palmitic acid diets were supplemented to provide 0.9% (study 1) and 1.2% (study 2) of total dietary fatty acids (DM basis). Compared with cows fed the CSFA diet in study 1, cows fed the SFA diet had 0.06 kg/d greater protein yield ($P = 0.01$) and 0.02 unit greater protein efficiency ($P = 0.01$) expressed as milk CP/CP intake. In study 2, cows fed the CSFA diet had 0.2 kg/d greater fat yield ($P = 0.04$), 0.1 unit greater fat efficiency ($P = 0.02$) expressed as milk fat/fat intake, 3.6 kg/d greater 3.5% FCM ($P = 0.04$), and 3.3 kg/d greater energy-corrected milk yield ($P < 0.05$). In conclusion, when cows started at 45 DIM and with a diet fat level of 5.1% (DM), the CSFA diet rich in oleic acid improved milk fat yield, milk fat efficiency, 3.5% FCM, and energy-corrected milk ($P < 0.05$). However, when cows started at greater than 70 DIM and with a diet fat level of 3.4% (DM), the SFA diet rich in palmitic acid improved lactation performance by improving milk protein yield and protein efficiency ($P < 0.05$). This study suggests that dietary fatty acids are potentially absorbed and partitioned differently depending on the level of dietary fat and DIM.

Key words: lactating dairy cow, milk fatty acids, rumen inert fat

INTRODUCTION

Cows in early lactation usually experience a period of negative energy balance, and dietary fat supplementation is an effective method to supply extra energy to dairy cows. Rumen inert fatty acids (**FA**) have been shown to improve milk performance (Schauff and Clark, 1992; Scott et al., 1995; McNamara et al., 2003). Calcium salts of FA are effective in improving milk performance (Schneider et al., 1988) because of their digestion in the lower digestive tract (Wu et al., 1991). Saturated fat is also a rumen inert source; however, a greater degree of saturation of FA results in less feed efficiency (Relling and Reynolds, 2007). In addition, the diet FA composition also results in differences in utilization efficiency by influencing the FA digestibility (deSouza and Lock, 2015). For example, C18:0 was more effective than C16:0 in providing energy for dairy cows during negative energy status (Drackley et al., 2001; Karcagi et al., 2010; Loften et al., 2014), whereas C16:0 was more effective than C18:0 in supplying energy to dairy cows during a period of positive energy status (Choi et al., 2013; Loften et al., 2014; deSouza and Lock, 2015).

The objective of this study was to compare the effects of 2 rumen inert fat sources [(1) Megalac (**CSFA**; Church and Dwight Co. Inc., Princeton, NJ) with greater C18:0 content than Palmit 80 (**SFAP80**; Global Agri Trade Corporation, Long Beach, CA) and (2) SFAP80 with greater C16:0 content than CSFA] on lactation performance of dairy cattle during the early-lactation period when cows would have a high demand for energy. In addition, there was a practical interest in evaluation of the intake inclusion rate of dietary fat in the diet because it differs geographically in the United States due to levels of milk production and heat and cold stress.

MATERIALS AND METHODS

Study 1 was approved by the Institutional Animal Care and Use Committee at Washington State University (IACUC protocol # 04428–001). Study 2 was approved by the College of Agriculture and Natural Resources Agricultural Animal Care and Use Committee, University of Delaware [Protocol # (17) 09–24–12 R].

The authors declare no conflict of interest.

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Animal, Management, and Treatment

In study 1, 24 multiparous cows were housed in a freestall facility bedded with composted manure solids. Cows were blocked by parity and predicted transmitting abilities and randomly assigned to 1 of the 2 treatment diets for the 12-wk study. The DIM at initiation of the study were 70 ± 43 (SD) d for the CSFA group and 77 ± 38 (SD) d for the SFAP80 group. The ration consisted of (DM basis) 19.6% corn silage, 35.5% alfalfa hay, 6.8% cottonseed, 5% corn distillers grains, and 33.1% grain mix. The diet was formulated with AMTS (Agricultural Modeling and Training Systems LLC, Groton, NY). Calcium salts of FA and SFAP80 were supplemented to provide extra FA at 0.9 and 1.2% of diet DM for study 1 and 2. Calcium salts of FA contained approximately 50.8% C16:0, 4.1% C18:0, 35.7% C18:1 *cis*, and 7% C18:2 of total FA (Megalac, Church and Dwight Co. Inc.). Saturated FA (Palmit 80, Global Agri Trade Corporation) contained less than 2% C14:0, 80% C16:0, 10% C18:0, 7% C18:1, and 1% C18:2 of total FA. Ingredients in the grain mix are shown in Table 1. The nutrient composition of the TMR is shown in Table 2. A partial TMR was made with all feed ingredients except the grain mix in a mixer wagon (Roto Mix 533–16 Hay Pro, Industrial Systems and Fabrication Inc., Spokane, WA). The partial TMR was then transferred into a Calan Super Data Ranger (American Calan, Northwood, NH), and respective grain mixes were added. Cows were fed individually using Calan gates once per day between 1000 and 1200 h. Feed was offered at 5 to 10% in excess of the previous day's intake. During the first 2 wk, all the cows were fed a TMR that contained 1.08% (DM) of CSFA, and data from these 2 wk were used as co-variate factors for analysis of data of wk 3 to 12. Beginning at wk 3, half of the cows in each block were randomly assigned to the SFAP80 diet or the CSFA diet.

In study 2, 30 multiparous Holstein dairy cows were used in a 14-wk study that consisted of 2 wk for diet adaptation and covariate data and a subsequent 12-wk period for diet comparison. Cows in the CSFA group started at 41 ± 24 (SD) DIM, and cows in the SFAP80 group started at 49 ± 24 (SD) DIM. All cows were housed in a free-stall facility bedded with sand. The ration consisted of (DM basis) 41.5% corn silage, 2.3% alfalfa hay, 10.3% haylage, and 45.9% grain mix. The ingredients in the grain mix are shown in Table 1. The composition of the TMR is shown in Table 2. Cows were individually fed once per d at 0800 h with Calan Super Data Ranger (American Calan). There was 10- to 14-d adaptation period when feeding the SFAP80 diet to ensure all cows were adapted to their Calan gates. Cows were blocked by their milk performance during the adaptation period and were randomly assigned to 1 of 2 dietary treatments. Treatments were either (1) a TMR supplemented with a ruminally inert fat of 1.2% DM (CSFA) or (2) a TMR supplemented with C16:0 FA of 1.2% DM. Cows were fed their respective TMR for 12 wk. The TMR was formulated with CPM-Dairy (V3.0.10, Ithaca, NY).

Data Collection and Analysis

Study 1. Samples of the TMR were obtained each wk for determination of DM. The amount of TMR offered and refused was recorded daily. Nutrient analyses of the TMR was conducted by wet chemistry at Cumberland Valley Analytical Services (Hagerstown, MD) and included CP, soluble protein, nonfiber carbohydrate, ADF, NDF, starch, acid hydrolysis fat (crude fat), ash, Ca, P, Mg, K, Na, Fe, Mn, Zn, and Cu.

Cows were milked twice daily (1100 and 2300 h), and milk yield was recorded with Dairy Comp 305 (Tulare, CA). Weekly a.m. and p.m. composite samples were taken and sent to the ID DHIA (Nampa, ID) for milk fat, protein, lactose, solids-not-fat, and SCC. Extra individual a.m. and p.m. milk samples were collected at wk 3, 7, and 12 (approximately DIM 85, 113, and 148), stored in the freezer (−20°C) without preservative, and later analyzed for FA as described by Jenkins (2010). All cows were evaluated for BCS once every other week. Scores were obtained by 2 individuals. The BCS was on the basis of a 1 to 5 scale with a quarter-change system (Edmonson et al., 1989). Individual BW was recorded on Monday of wk 1, 7, and 12.

Study 2. Cows were milked twice daily (0600 and 1600 h), and milk weights were recorded at each milking. Individual a.m. and p.m. composite milk samples were collected 2 to 3 d at the end of the adaptation period and served as co-variant for wk 1 to 12. Individual a.m. and p.m. composite milk samples were collected on Tuesday and Friday of each wk.

The amount of TMR offered and refused was recorded daily. Samples of each TMR were collected 3 times each wk and composited every 2 wk for nutrient analyses. The DM contents of silages were analyzed each wk (48 h in 60°C forced-draft oven) and used to adjust the proportions of feeds in the TMR.

Body weights were recorded on 2 consecutive days at the start of the treatment period and once on wk 2, 4, 6, 8, 10, and 12. Body condition score was taken during the pretreatment period and wk 7 and 12 of the study by 2 individual persons with a quarter-change point system (Edmonson et al., 1989).

Milk samples were analyzed by Dairy One Cooperative Inc. (University Park, PA) for fat, protein, lactose, and SCC. Approximately 30 mL of representative samples from the pretreatment period and wk 1, 3, 5, 7, 9, and 11 of the treatment period from one day's a.m. and p.m. milking was frozen without preservative for analysis of milk FA according to Jenkins (2010).

Nutrient analyses of TMR were conducted by wet chemistry methods by Cumberland Valley Analytical Services (Hagerstown, MD; Table 2). The procedures were the same as in study 1.

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