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Supplementing different ratios of short- and medium-chain fatty acids to long-chain fatty acids in dairy cows: Changes of milk fat production and milk fatty acids composition

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ABSTRACT

Milk fat synthesis might be promoted by the dietary addition of long-chain fatty acids (LCFA) or short- and medium-chain fatty acids (SMCFA). This study evaluated unprotected lipid supplementation with different ratios of SMCFA to LCFA, which had equivalent fatty acid (FA) proportions (by weight) to those in milk, on milk fat production and milk FA composition. Thirty-six Holstein cows (183 ± 46 d in milk) were divided into 3 treatments according to a randomized block design. Cows in 3 treatments received supplements of 80 g/d of SMCFA mixture and 320 g/d of LCFA mixture (ratio of SMCFA to LCFA was 20:80); 400 g/d of butterfat (ratio of SMCFA to LCFA was 40:60); or 240 g/d of SMCFA mixture and 160 g/d of LCFA mixture (ratio of SMCFA to LCFA was 60:40). The FA compositions of the SMCFA mixture and the LCFA mixture were similar to the de novo synthesized FA (except C4:0) and preformed FA (except *trans* FA) found in the butterfat, respectively. Fatty acid supplements and butterfat were consumed by cows daily before the morning feeding during the 8-wk experimental period. Dry matter intake and milk yield were not different among the treatments. The milk fat percentage and total SMCFA concentration in milk fat tended to increase linearly and the proportion of milk total solids increased linearly with increasing ratios of SMCFA to LCFA in the supplements, whereas milk fat yield was not changed. We suggest that increasing ratios of SMCFA to LCFA in diets has the potential to improve milk fat synthesis.
Key words: short- and medium-chain fatty acid, long-chain fatty acid, milk fat, milk fat synthesis

INTRODUCTION

Milk fat, which represents the major economic value of milk, is the substantial component contributing to the energy density of whole milk and dairy products and accounts for many of their physical properties, processing attributes, and organoleptic qualities (Harvatine et al., 2009). Compared with other solid components in milk, fat concentration is the most sensitive to the dietary influences (Sutton, 1989). The effect of dairy cow nutrition on milk fat composition and yield has been reviewed extensively (Lock and Bauman, 2004; Jenkins and McGuire, 2006; Harvatine et al., 2009). But the studies that demonstrated consistent ways to increase milk fat concentration are limited.

The addition of saturated long-chain fatty acids (**LCFA**) tended to increase milk fat yield (Steele and Moore, 1968a; Drackley et al., 1992), but the de novo synthesis of short- and medium-chain fatty acids (**SMCFA**) by mammary gland cells was inhibited by the exogenous LCFA (Hansen and Knudsen, 1987a,b). The SMCFA (C4–C14) and about half of C16, which form de novo from circulating acetate and BHBA in the mammary gland, make up 40% of all the milk FA (Chilliard et al., 2000); LCFA (the carbon chain length >C16) along with the other half of C16, which originate from feed and body adipose tissues (Mansbridge and Blake, 1997; Kalač and Samková, 2010), comprise 60% of all FA in the milk (Chilliard et al., 2000). Steele and Moore (1968a) reported that the milk fat percentage was increased when myristic acid and palmitic acid were supplemented to the diet of lactating cows. Researchers inferred that the provision of SMCFA via dietary means might enhance milk fat content (Kadegowda et al., 2008; Vyas et al., 2012). Kadegowda et al. (2008) reported abomasal infusion of butterfat—containing both SMCFA and LCFA with FA composition identical to that of milk—increased milk fat percentage and yield, whereas infusion of only the LCFA present in the butterfat had no effect.

Thus, we hypothesized that unprotected fat supplements with different ratios of SMCFA to LCFA would have diverse influences on milk fat production, and milk fat synthesis might be promoted. In this study, the effect of different ratios of SMCFA to LCFA (20:80, 40:60, and 60:40) on milk fat synthesis and milk FA composition was evaluated.

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MATERIALS AND METHODS

Experimental Design and Treatments

The present study was performed at Beijing Cangdafu Dairy Farm (Beijing, China). Animals were cared for in accordance with the guidelines established by the Institute of Animal Science, Chinese Academy of Agriculture Science, Beijing, China.

Thirty-six lactating Holstein cows were blocked by average daily milk yield, DIM, and parity (183 ± 46, 21 ± 3.37 kg/d, and 1.83 ± 1.25, respectively) and then randomly assigned to 1 of 3 treatments, each treatment consisting of 12 cows. Treatment supplements were added to diets as follows: (1) 80 g/d of SMCFA mixture and 320 g/d of LCFA mixture (**20SM80L**; ratio of SMCFA to LCFA was 20:80); (2) 400 g/d of butterfat (**40SM60L**: ratio of SMCFA to LCFA was 40:60); or (3) 240 g/d of SMCFA mixture and 160 g/d of LCFA mixture (**60SM40L**; ratio of SMCFA to LCFA was 60:40). The FA compositions of the 3 treatment supplements are presented in Table 1. Except for butyrate in the SMCFA and *trans* FA in the LCFA, the FA compositions of the SMCFA mixture and LCFA mixture were similar to the FA derived from de novo synthesis and preformed FA in butterfat (Bright Dairy Co., Shanghai, China), which contain all FA with composition identical to milk. Because the amount of *trans*-10,*cis*-12 conjugated linoleic acid (**CLA**) in butterfat is less than the effective dose for milk fat depression (Peterson et al., 2002), the inhibitory effect of *trans*-10,*cis*-12 CLA in the butterfat was neglected. The SMCFA mixture included 6% caproic acid (C6:0), 4% caprylic acid (C8:0), 9% capric acid (C10:0), 10% lauric acid (C12:0), 32% myristic acid (C14:0) and 39% palmitic acid (C16:0; Guanhua Co. Ltd., Nanjing, China). The LCFA mixture included 59% cocoa butter (major FA by weight percentage were C12:0, 1.25%; C16:0, 24.64%; C18:0, 35.55%; *cis*-9 C18:1, 32.91%; C18:2, 3.45%; Linzhishanyang Co. Ltd., Jiangsu, China), 16% olive oil (major FA by weight percentage were: C16:0, 9.43%; C18:0, 2.86%; *cis*-9 C18:1, 72.81%; C18:2, 12.20%; Shijikangxin Ltd., Beijing, China), and 25% palm oil (major FA by weight percentage were: C16:0, 47.12%; C18:0, 4.69%; *cis*-9 C18:1, 37.39%; C18:2, 9.67%; Yihai Ltd., Shanghai, China).

Because about half of the C16:0 is formed de novo (the other half originates from feed and body adipose tissues; Kalač and Samková, 2010), only 50% of the C16:0 found in the butterfat was included in the both SMCFA mixture and LCFA mixture. The SMCFA mixture provided 50% of the C16:0 and equivalent proportion (by weight) of C6:0, C8:0, C10:0, C12:0, and C14:0 FA as those found in the butterfat. The LCFA mixture provided 50% of the C16:0 and equivalent proportion

Table 1. Fatty acid composition of FA supplements in treatments

	Treatment,[2] g/100 g of total FA		
FA[1]	20SM80L	40SM60L	60SM40L
4:0	0.00	3.92	0.00
6:0	1.23	2.28	3.71
8:0	0.81	1.34	2.35
10:0	1.80	3.27	5.36
12:0	2.68	3.75	6.61
14:0	6.50	11.08	18.62
14:1	0.00	1.53	0.00
15:0	0.00	1.18	0.00
16:0	30.05	28.82	33.37
16:1	0.25	1.29	0.32
17:0	0.14	0.57	0.07
18:0	18.18	10.85	9.08
cis-9 18:1	32.44	20.98	16.82
trans-11 18:1	0.03	3.35	0.02
Conjugated linoleic acid	0.11	1.72	0.06
18:2	5.14	2.53	3.30
18:3	0.26	0.88	0.13
20:0	0.37	0.25	0.19
cis-8,11,14 20:3	0.00	0.01	0.00
cis-11,14,17 20:3	0.00	0.17	0.00
Others	0	0.22	0

[1]Expressed as numbers of carbons:numbers of double bonds.

[2]20SM80L = supplemented with 400 g/d of FA supplement, containing 20% short- and medium-chain fatty acid (SMCFA) mixture and 80% of long-chain fatty acid (LCFA) mixture; 40SM60L = supplemented with 400 g/d of butterfat, providing 40% SMCFA and 60% LCFA (approximately); 60SM40L = supplemented with 400 g/d of FA supplement, containing 60% SMCFA mixture and 40% LCFA mixture.