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Management practices, physically effective fiber, and ether extract are related to bulk tank milk de novo fatty acid concentration on Holstein dairy farms

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ABSTRACT

The objective of this study was to evaluate the relationship of management practices and dietary factors with de novo fatty acid concentration in bulk tank milk from commercial dairy farms milking Holstein cows. Farms were selected based on de novo fatty acid concentration during the 6 mo before the farm visit and were categorized as high de novo (HDN; 24.61 ± 0.75 g/100 g of fatty acids, mean ± standard deviation; n = 19) or low de novo (LDN; 23.10 ± 0.88 g/100 g of fatty acids; n = 20). Farms were visited once in February, March, or April 2015 and evaluated based on management and facility design known to affect cow behavior, physical and chemical characteristics of the diet, and ration formulation and forage analyses obtained from the farm's nutritionist. We observed no differences between HDN and LDN farms in farm size, time away from the pen for milking, days in milk, or body condition score. We detected no differences between HDN and LDN farms in milk fat or true protein yield; however, milk fat and protein content and de novo fatty acid yield per day were higher for HDN farms, as was gross income per unit of milk sold. High de novo farms tended to be more likely to deliver fresh feed twice versus once per day, have a freestall stocking density ≤110%, and provide ≥46 cm of feed bunk space per cow. We observed no detectable differences in forage quality or ration dry matter, crude protein, or starch content. However, ether extract was lower and physically effective neutral detergent fiber was higher for HDN farms. Feeding management, stocking density, dietary ether extract content, and the physical characteristics of the diet are related to de novo fatty acid, fat, and protein concentration in bulk tank milk from high-producing Holstein dairy farms.
Key words: de novo fatty acids, milk fat, milk protein

INTRODUCTION

De novo milk fatty acids (**FA**; C4 to C14) are those that are synthesized in the cow's mammary gland using acetate and butyrate—VFA that originate from the fermentation of fibrous feeds in the rumen (Palmquist et al., 1993). Mixed-origin milk fatty acids (C16) can be synthesized in the mammary cells from acetate and butyrate or can enter the mammary secretory cell preformed; at present, no method exists to determine these separately. Preformed FA (≥C18) enter the mammary cell from the blood stream and originate from the cow's intestinal, liver, or adipose tissues.

A large and systematic change in the fatty acid composition of milk fat occurs with stage of lactation (Lynch et al., 1992); de novo FA start out as low a proportion of total FA in early lactation and increase to a relatively constant concentration when cows are in positive energy balance. In high-producing Holstein cows, de novo FA typically account for 18.2 to 28.4% of the total FA in milk fat (Jensen, 2002). Factors that affect ruminal conditions, such as nutrition and management, may influence milk fatty acid profiles and are the predominant factors that affect milk de novo fatty acid synthesis among cows of similar breed and stage of lactation (Palmquist et al., 1993; Bauman and Griinari, 2003).

High dietary carbohydrate fermentability and excessive ruminally available PUFA may depress de novo fatty acid synthesis (Harvatine and Bauman, 2011). Dietary fat supplementation may also influence milk fat composition by directly providing substrate for preformed milk FA (Stoffel et al., 2015), although the extent of fatty acid variation may be limited by the melting point of milk fat (Toral et al., 2013). Adequate physically effective NDF (**peNDF**; 20 to 23% of ration DM; Mertens, 2002) has been associated with an increase in ruminal pH (Allen, 1997; Kononoff and Heinrichs, 2003) and greater milk fat (Grant et al., 1990) and milk protein content (Caccamo et al., 2014). However, to our knowledge no studies have evaluated

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the relationship between the physical characteristics of the diet and bulk tank de novo FA concentration on commercial Holstein dairy farms.

In addition to the diet, feeding environment may also influence milk composition. For example, stocking density and facility design may influence feeding behaviors such as increasing feeding rate (Collings et al., 2011) or sorting against long particles (Sova et al., 2013), which increase a cow's risk for low ruminal pH (French and Kennelly, 1990). Management practices and dietary characteristics that result in low ruminal pH are associated with reduced milk fat content (Allen, 1997) via a shift to the alternate ruminal biohydrogenation pathway, leading to the formation of UFA isomers that downregulate the expression of genes related to de novo FA synthesis (Harvatine and Bauman, 2011).

Previous research has evaluated the relationship between management practices and bulk tank milk de novo FA content for lower-producing, smaller dairy farms that contain a variety of breeds (Woolpert et al., 2016), and it has predicted FA composition using data that describe the source and proportion of forages in the diet (Coppa et al., 2013). However, we need to better understand the relationships among cow management practices, dietary fat content, peNDF, and de novo FA concentration for high-producing Holstein dairy farms. The objectives of this study were to evaluate management practices, dietary chemical composition and physical characteristics, and lactation performance for high-producing Holstein dairy farms with high or low de novo FA concentrations in bulk tank milk. We hypothesized that Holstein dairy farms that optimized cow comfort and fed adequate peNDF would have higher de novo FA concentrations and higher milk fat and protein content in bulk tank milk.

MATERIALS AND METHODS

On-Farm Data Collection

Farms were enrolled based on their willingness to participate in the study and the concentration of de novo FA in bulk tank milk samples taken 2 to 20 times per month for each farm over the 6 mo before the the study began. Farms were categorized as high de novo (**HDN**) or low de novo (**LDN**) based on their average de novo FA concentration (g/100 g of FA) for the 6 mo before the farm visit (September 2014 to February 2015; Table 1). To be eligible to participate in the study, farms needed to be a member of the St. Albans Cooperative Creamery (St. Albans, VT), average at least 25 kg of milk per cow per day, have 90% or more Holstein cattle, milk at least 50 cows, and calve year-round. Each farm was visited once between February 25 and April 24, 2015.

Management practices, BCS, and herd demographics were recorded by trained research personnel from Miner Institute (Chazy, NY), working with a farm owner or manager. The primary management factors assessed were stall stocking density, feed bunk space per cow, feeding frequency, feed push-up frequency, time away from pen for milking, and milking frequency.

Diets were sampled for chemical composition analysis as described by Woolpert et al. (2016). Previous research had found no detectable differences in the chemical composition of corn silage or hay crop silage for HDN versus LDN herds (Woolpert et al., 2016), so analysis of these components was omitted from the study. However, the most recent hay crop silage and corn silage analyses were obtained from the farm's nutritional consultant to assess the content of DM, CP,

Table 1. Milk composition data (used to select farms to participate in the study) representing monthly mean milk composition for high de novo (HDN; n = 19) and low de novo (LDN; n = 20) farms from September 2014 to February 2015

	HDN			LDN		
Item	Mean ± SD	Minimum	Maximum	Mean ± SD	Minimum	Maximum
Fat, %	3.96 ± 0.15	3.72	4.19	3.75 ± 0.19	3.43	4.15
True protein, %	3.19 ± 0.09	2.99	3.32	3.10 ± 0.07	2.98	3.20
De novo fatty acids (FA)[1]						
g/100 g of milk	0.92 ± 0.05	0.79	1.00	0.81 ± 0.06	0.72	0.92
g/100 g of FA	24.61 ± 0.75	22.57	26.15	23.10 ± 0.88	21.22	24.45
Mixed FA[2]						
g/100 g of milk	1.53 ± 0.09	1.37	1.68	1.41 ± 0.11	1.19	1.65
g/100 g of FA	41.15 ± 1.04	39.28	43.35	39.94 ± 1.42	36.91	42.29
Preformed FA[3]						
g/100 g of milk	1.27 ± 0.05	1.16	1.34	1.30 ± 0.05	1.20	1.41
g/100 g of FA	34.42 ± 1.35	31.99	37.31	36.96 ± 1.86	34.02	40.74

[1]C4 to C14.

[2]C16, C16:1, and C17.

[3]Greater than or equal to C18.