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Perspective: A commentary on the effect of palmitic acid feeding on thermal properties of milk fat

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PERSPECTIVE

A recent controversy in Canada began on social media (Twitter) with a cookbook author claiming that she thought butter was "no longer soft at room temperature" (Van Rosendaal, 2021). Further social media discussion and press reporting proposed that feeding palmitic acid fat supplements to dairy cows was the cause of harder butter. Subsequently, the story was nicknamed "Buttergate" and purported that farmers were feeding palmitic acid to increase milk fat; reporting focused heavily on the controversial environmental impacts of palm oil production (BBC, 2021). This media storm highlights the importance of understanding the effects of nutrition and management on dairy products and considering consumer perceptions of on-farm practices. Milk is a commodity and many opportunities exist to improve communication and understanding among producers, processors, and consumers and between the dairy production and processing research fields. This brief perspective highlights some important considerations of the biology relevant to the potential effects of feeding palmitic acid supplements on properties of milk fat, as well as key literature important to the current conversation.

The melting characteristics of milk fat are affected by several chemical and physical properties and can be modified by nutritional and physiological factors. A complete review is outside of the scope of this brief article, but a YouTube video presentation introducing some of the biology of milk fat synthesis relevant to the discussion was recently made by Dr. Adam Lock (Lock, 2021) and is partly covered by Loften et al. (2014). Briefly, the melting temperature of milk fat is affected both by the melting temperature of the individual fatty acids (**FA**) and their position in the triglyceride. Short-chain FA have much lower melting temperatures than long-chain FA, and unsaturated fatty acids (UFA) have much lower melting temperatures than their corresponding saturated fatty acids (SFA). Feeding fat supplements modifies the FA profile of milk, but the response is different between 16- and 18-carbon fat supplements. Palmitic acid supplements increase palmitic acid (16:0) in milk fat and generally have less of an effect on short- and medium-chain fatty acids than do 18C fatty acids. Last, feeding unsaturated 18-carbon fat results predominantly in an increase in saturated fat absorption due to extensive rumen biohydrogenation of UFA.

A major consideration that has been largely overlooked in the larger discussion of the effect of palmitic acid on melting properties of milk fat is that although intake of both 16- and 18-carbon FA results in absorption of saturated fat, there is a major difference in the rate of desaturation of palmitic and stearic acids. Approximately 50% of stearic acid is converted to oleic acid in the mammary gland (Enjalbert et al., 1998), resulting in a 55.9°C decrease in melting temperature of the FA with this desaturation. However, only ~5% or less of palmitic acid is converted to palmitoleic acid based on the "desaturase ratio," calculated as the product-to-precursor ratio (Kelsey et al., 2003). The desaturation of stearic acid is likely a major player in modifying the melting temperature of milk fat, but the biological capacity for this mechanism is very limited for palmitic acid. The resulting biochemical differences provide the potential for palmitic acid to have a greater impact on the melting properties of milk fat than stearic acid or unsaturated 18-carbon FA that are biohydrogenated in the rumen.

Very limited work has been done on the effect of dairy nutrition in general, and palmitic acid supplements specifically, on the melting properties of milk fat. Briefly, Ortiz-Gonzalez et al. (2007) reported the effect of abomasal infusion of oils that contained 40% palmitic acid in combination with either mostly stearic acid (40%) or oleic acid (37%). They found no change in melting temperature or solid fat content at 5°C and 20°C, although addition of oleic acid decreased force to fracture. It is interesting to note that these mixtures of palmitic and 18C FA did not increase palmitic acid in milk fat. Enjalbert et al. (2000) determined the per-

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centage of fat that was solid at different temperatures from cows abomasally infused with 500 g/d of highly enriched palmitic, stearic, or oleic acid. There was no difference in the percentage of solid fat between control, palmitic acid, and stearic acid treatments between −10 and 12°C. However, the solid fat content of milk fat from the palmitic treatment was >24% higher than that of the control and stearic acid treatments at 18°C, >34% greater than that of the control and stearic acid treatments at 24°C (10.2 and 12.7 percentage units higher), and >70% greater than that of the control and stearic acid treatments at 30°C (15.7 percentage units higher). Chamberlain et al. (2016) compared textural and thermal properties of butter from cows fed supplements with high and low levels of palmitic acid at 2% of diet (496 g/d intake) and observed increased hardness and melting properties with the supplement high in palmitic acid, including an increase in hardness at ambient temperature (force 1.51 vs. 0.35 N). We have similarly observed an increase in the melting temperature of milk fat from cows fed a high palmitic acid supplement compared with cows fed no fat supplement control or stearic acid (18:0; unpublished data). Clearly, feeding palmitic acid has the potential to change the thermal properties of milk fat, but it is not clear whether these differences are practically relevant or occurring to a noticeable degree in the current milk markets. It is important to note that the potential influence of palmitic acid would depend on the average feeding level and other factors across all farms supplying milk to each processing plant.

Nearly all feeds contain palmitic acid, and palm-based fat supplements have been fed for many decades. The effect on melting properties of milk fat likely depends on the amount of palmitic acid provided by the entire diet and potentially also by the ratio of 16- and 18-carbon fatty acids, based on the contrasting results from experiments feeding palmitic acid mixtures (Ortiz-Gonzalez et al., 2007) and highly enriched supplements (Enjalbert et al., 2000) discussed above. Many supplements commercially available over the past decade are highly enriched in palmitic acid (>85%) and increase palmitic acid intake and 16-to-18C FA ratio quickly. Last, milk palmitic acid synthesis is affected by other factors such as acetate supply, season of the year, and genetic factors, all of which need to be integrated into the larger discussion.

Milk fat has very complex melting properties and it may be helpful to think of it as a mixture of solid and liquid fat, with an increasing proportion of liquid as butter softens during warming. This dynamic temperature-dependent nature changes the effect for different products. For example, there may be little difference in percent solid at refrigerator temperature, significant differences at room temperature, and no difference while warm after cooking. Thus, the effect may be important for table butter or cheese consumed cold but not for cheese served warm (e.g., on pizza). The question is not whether and how much palm fat to supplement in feed, but what are the targeted thermal properties of milk fat and what is the fatty acid profile required to meet this goal. Palm fat supplements then become one factor by which to modify milk thermal properties, and the feeding level will need to consider diet conditions, season, genetics, and other factors. Reaching a targeted melting characteristic may need to be balanced with meeting total demand for milk fat. However, the ideal characteristics may differ between products, allowing specific recommendations based on products being made.

Regardless of the controversy around palmitic acid and whether the melting properties of butter have changed, it appears that at least some consumers would prefer a butter that is softer. Softer butters and butter spreads are available in the marketplace and are based on either blending with UFA or specific manufacturing methods, but some consumers may not realize these are available or prefer a "normal" butter that previously met their needs. I find it exciting that consumers and processors are interested in the melting properties of milk fat and that we have the potential to deliver a product that better meets consumer needs and desires. This will require civil and effective communication among consumers, processors, and producers to understand the targets, as well as between dairy production and dairy processing experts to develop solutions. Thus, we have an opportunity to move beyond producing and processing commodity "milk fat," to better meet consumer demands, and, we hope, earn a premium for the effort. There are likely other nutrition and management factors that influence processing, product quality, flavor, and consumer acceptability that deserve our attention.

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