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# *Perspective:* A commentary on elevated palmitic acid levels in Canadian butter and their relationship to butter hardness

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## PERSPECTIVE

Most dairy researchers and dairy industry stakeholders have likely taken note of "Buttergate" in Canada by now. It has garnered much attention from the public, media, industry representatives, and government agencies (https://lnkd.in/guAqvHH). It started on Twitter and ended up as an article in a leading Canadian national newspaper on February 20, 2021 (https://www.theglobeandmail.com/life/food-and-wine/article-is-your-butter-not-as-soft-as-it-used-to-be-the-pandemic-and-our-urge/). This was quickly followed on February 23 with a news opinion piece by the well-known agrifood economist Dr. Sylvain Charlebois from the Agri-Food Analytics Laboratory at Dalhousie University (https://montreal.ctvnews.ca/opinion-buttergate-and-the-hard-truth-about-canadian-butter-1.5320211). Palm oil supplementation of cows' feed was identified as the probable cause of harder Canadian butter.

All of this activity took place without data on the association between high palmitic acid content in butterfat (also called milkfat) and mechanical hardness in commercial butter samples. We thus decided to look into the matter in detail and analyze commercially available butters to determine whether fatty acid composition and mechanical hardness were correlated.

A quick internet search on palm oil and cow feed supplements yields high-quality scientific papers on the subject. In a paper by Chamberlain et al. (2016), the authors fed 12 lactating Holstein cows supplements high and low in palmitic acid. The palmitic acid content in the milkfat produced by cows whose feed was supplemented with 2% palmitic acid (as a percentage of total feed weight) increased from 28% to 40%. The authors demonstrated an increase in fat content of the milk associated with palmitic acid supplementation, and showed that butter made from milk with a high palmitic acid content was much harder than that made from milk with a low palmitic acid content. In another study by the same group, Chamberlain and DePeters (2017) supplemented the feed of 4 cannulated Holstein cows with different ratios of palmitic acid and stearic acid. They observed that 2% palmitic acid supplementation of the feed increased the palmitic acid content of the milkfat from ~30% (wt/wt) to 40% (wt/wt). Chamberlain et al. (2016), Chamberlain and DePeters (2017), and de Souza and Lock (2019) have demonstrated how palmitic acid supplementation increases the total yield of fat via increases in the milkfat content of milk.

The fact that milk fatty acid composition affects butter hardness has been clearly demonstrated in the literature (Bobe et al., 2003). Ortiz-Gonzalez et al. (2007) even demonstrated that by changing feed composition, the triglyceride composition—and thus solid fat content and melting profiles—of the milkfat can be altered.

Returning to the issue at hand, a more pertinent question is why farmers would add palmitic acid to the feed of cows. Palmitic acid is a useful source of energy for the lactating cow because it increases milkfat levels and farmers in Canada are paid based on the fat content of the milk they produce. It is also perfectly safe for the animal (Chamberlain and DePeters, 2017). Being a saturated fatty acid (SFA), palmitic acid is not hydrogenated in the rumen and thus does not affect rumen physiology.

Given these well-established facts, what is all the fuss about? We think this is a great example of a perfect media storm. First, we have consumer ignorance of how milk and food is produced. Many consumers have an image in mind of artisanal food production from a non-technological era, but still expect their food to be plentiful and cheap. Second, we have a mixed and weak response from the dairy processing industry and from organizations representing milk producers. Third, we have an opportunistic news industry searching for the next crisis on which to report. These 3 factors combined to create the "Buttergate" phenomenon.

Being lipid chemists, we must add a technical note on palm oil and palmitic acid. Palmitic acid is the most common SFA in nature and it is found in both animal and plant tissues. For example, soybean oil contains

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~16% palmitic acid, cottonseed oil contains ~25% palmitic acid, and palm oil contains ~45% palmitic acid. Palmitic acid can be derived from cottonseed oil or other crops. Would consumers feel differently if palm oil were not the source of the palmitic acid? The negative sustainability image of palm oil may have played a part in all of this. However, if we are really concerned about palm oil and its negative sustainability footprint, we should stop eating most bakery, confectionery, and culinary products on the market, because those contain almost exclusively palm oil or its fractions. This would have a much greater impact on palm oil utilization than discontinuing the feeding of palmitic acid to dairy cows.

However, we have still not addressed the issue of whether butter in Canada is high in palmitic acid and thus harder than usual. To answer this question, we purchased 21 commercial butter samples from local supermarkets in Ontario and Alberta (work with butter from Eastern and Western Canada is ongoing). The purchased samples included standard brands, as well as organic, grass-fed, artisanal, flavored, and upscale brands. This was simply a convenience sample, not intended to be a comprehensive, extensive, or complete sample. Samples were stored at either 8°C or 20°C for 3 d before hardness measurements were carried out using constant-rate mechanical testing and a plexiglass cone plunged directly into the middle section of standard 1-lb blocks of butter (2 samples were 0.5 lb blocks but of equal width to the 1-lb samples), well away from the sides to avoid edge effects. As a technical note, individually wrapped 0.25-lb sticks cannot be analyzed like this because they break upon cone penetration and the edge effects are large. We also performed milkfat extraction and fatty acid analysis by standard gas-liquid chromatography techniques. We then proceeded to plot firmness (maximum force at 12 mm penetration at a constant speed of 1 mm/s) at refrigeration (8°C) and room (20°C) temperatures as a function of different fatty acid contents and ratios thereof. We also collected values on work of penetration, but these results mirrored those of firmness. The results obtained and methods used are available in supplemental files available online (https://doi.org/10.7910/DVN/6W9QCP). Although many correlations were found, Figure 1 shows only those with the highest correlation coefficients.

It can be seen that the correlations were heavily biased by one low and one high palmitic acid:oleic acid sample, with most samples being clustered in the middle of the range. The spread of the data is not ideal, but a larger sample could also be bimodal. Most correlations were statistically significant but those with the highest correlation coefficients included the positive correlation of firmness with palmitic acid content (Figure 1A), the negative correlation of firmness with oleic acid content (Figure 1B), and the positive correlation of firmness with palmitic acid:oleic acid ratio (Figure 1C). Overall, a high SFA content should yield a harder fat, whereas a high unsaturated fatty acid (UFA) content should yield a softer fat. However, it is slightly more complex than this because fatty acids are assembled into triglyceride molecules, in combinations of 3 fatty acids per triglyceride molecule. These can be a mixture of SFA and UFA, with a resultant wide range of melting points. Depending on the temperature, an SFA can be part of

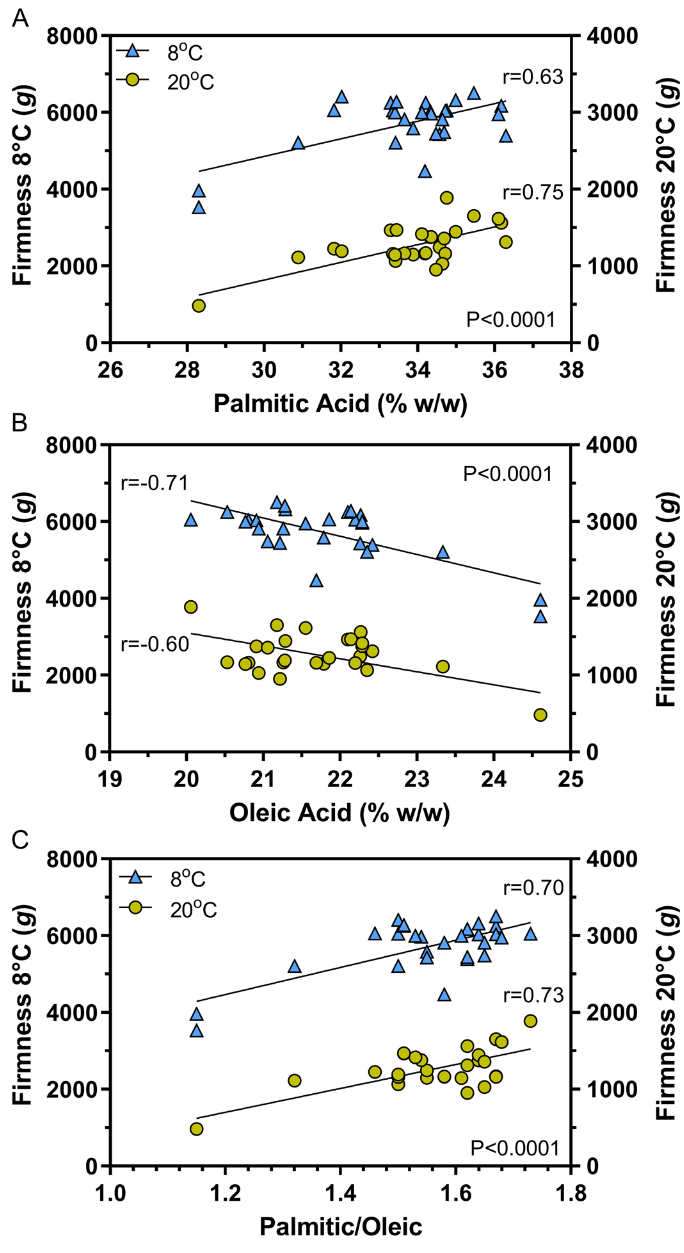


**Figure 1.** Relationship between mechanical firmness of butter and corresponding milkfat (A) palmitic content, (B) oleic acid content, and (C) palmitic acid:oleic acid ratio.

a liquid or solid triglyceride (e.g., 1-palmitoyl-2-oleyl-3-oleyl-*sn*-glycerol vs. 1-pamitoyl-2-oleyl-3-palmitoyl-*sn*-glycerol). This confounds correlations between fatty acid composition and mechanical properties. The more informative correlation would be between firmness and specific triglyceride molecular species.

These preliminary results suggested that butter firmness, at both 8°C and 20°C, was positively correlated with palmitic acid content, negatively correlated with oleic acid content, and positively correlated with the palmitic acid:oleic acid ratio. Firmness and palmitic acid content at 20°C had the highest correlation coefficient of all combination studies to date (r = 0.75, $P < 0.001$). However, a correlation coefficient of 0.75 yields an $R^2$ of 0.56, which indicates that only 56% of the variation in firmness was explained by palmitic acid content. Other factors could include processing effects. In a high-throughput manufacturing plant, if fats do not spend enough time being softened by mechanical working and are not tempered at the appropriate temperature for some time, they become harder and more brittle. Thus, we assume that the combination of increased palmitic acid content and higher plant throughput due to large increases in butter demand interacted to create the harder-than-usual butter.

The other question is whether palmitic acid levels in Canadian butter were higher than usual or had increased recently beyond variations attributable to seasonal feed composition changes.. In the absence of historical milkfat data, this is difficult to ascertain. Published fatty acid compositions of milkfat indicate levels of ~28% palmitic acid (Jensen, 1995; O'Donnell-Megaro et al., 2011). The Canadian Nutrient File reports a fatty acid composition for butter (https://food-nutrition.canada.ca/cnf-fce/report-rapport.do), which was last updated in 2015. Surprisingly, that report indicates a palmitic acid content of milkfat of 26% (wt/wt). We determined that the palmitic acid content in the milkfat isolated from the commercial butters ranged from 28.3% to 38.6%, with most of the samples being at the high end of the range. All but one of the butters analyzed had high palmitic acid levels compared with the Canadian Nutrient File, USDA databases, and several scientific publications. Why do we observe this discrepancy? This is a more complex question that only a more comprehensive study can answer.

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