Richard Kirkland
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The role of palm oil in a sustainable dairy industry

This is the final article in the series looking at issues relating to the sustainability and use of palm oil in the dairy industry. The articles have covered the following topics :

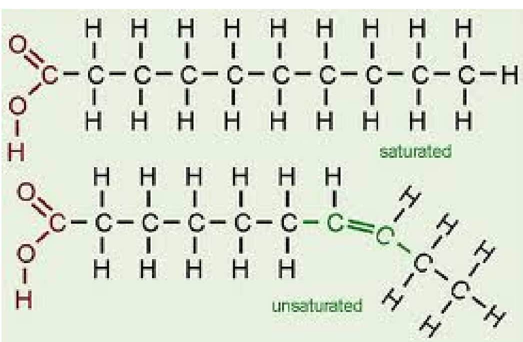
1. Palm oil in a sustainable world
2. Efficient milk production and role of fat
3. UK's first fat supplement manufactured using only certified sustainable palm oil
4. **Saturated fats in milk**

4. Saturated fats in milk

Previous bulletins in this series have considered the sustainability of palm oil and the important role dietary fat plays in promoting an efficient dairy industry. This bulletin looks specifically at saturated fatty acids (SFA) and their presence in milk.

What are SFA ?

All fatty acids are composed of a chain of carbon atoms, surrounded by hydrogen, with a carboxyl (COOH) group at one end. Most naturally occurring fatty acids have a chain consisting of an even number of carbon atoms ranging from 4 to over 20 and they can be categorised as either SFA or unsaturated fatty acids (USFA).



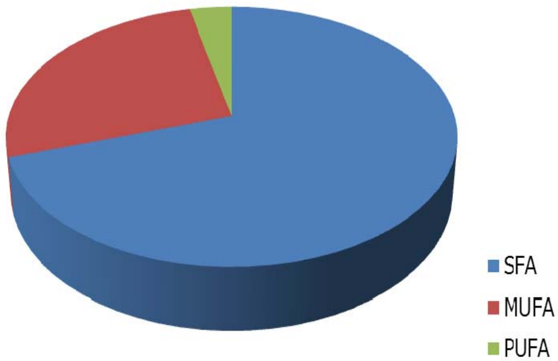
The difference between SFA and USFA relates to the number of hydrogen atoms in the chain. In SFA all the carbon atoms in the chain are surrounded by hydrogen. In contrast, USFA do not have hydrogen atoms surrounding all the carbons in the chain and instead have arrangements known as 'double bonds' (C=C) (Figure 1).

Figure 1 Structure of saturated and unsaturated fatty acids

Fatty acids are named according to the number of carbons in the chain and the number of double bonds. Hence, palmitic acid which contains a 16-carbon chain and no double bonds is denoted as C16:0 (indicating it is a SFA), whereas oleic acid which contains an 18-carbon chain and one double bond is denoted as C18:1 (indicating it is an USFA).

SFA in milk

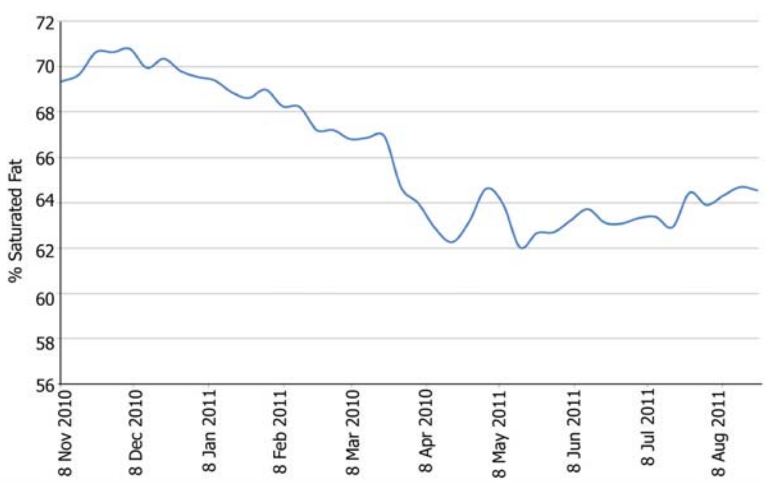
Concentration of total fat in milk from dairy cows in the UK is low, averaging 3.96% during the 2010/11 milk year (DairyCo).



However, concentration of SFA in milk fat is high, typically around 70%, with the remainder composed of mono-unsaturated fatty acids (MUFA; containing one double bond) and poly-unsaturated fatty acids (PUFA; containing two or more double bonds) (Figure 2).

Figure 2 Typical fatty acid profile of milk

Fatty acid profile of bulk milk deliveries vary considerably throughout the year, reflecting major changes in diet composition as cows move from typical high concentrate, low forage winter rations to more forage-based rations at turnout to grazing. Figure 3 presents average weekly SFA concentration in milk of NML-recorded herds in Great Britain from November 2010 through to August 2011 (represents approximately 55,000 bulk tank measurements per month).



These data show that concentration of SFA peaked at just over 70% in mid-winter but reached a trough of 62% in early summer.

Concentration of SFA can also vary greatly between individual cows and farms.

Figure 3 Average SFA in NML-recorded herds in GB (November 2010 to August 2011) (Bartlett; NMR)

Recommendations for SFA intake and contribution from dairy products

Consumption of SFA has been associated with increased plasma cholesterol concentration, potentially increasing the risk of cardiovascular disease (CVD). While government targets are for no more than 11% of energy intake to come from SFA, recent UK data indicate that this target is exceeded by an average of 20-22%. Hence, in 2009 the Food Standards Agency (FSA) launched a public health campaign aimed at reducing consumption of SFA in the UK; a 1% reduction in intake of energy from SFA could decrease risk of CVD by 3%.

Milk and dairy products are the single largest source of SFA in the UK diet. Dairy products contribute around 40% of total SFA intake (Figure 4) and approximately 60% of this arises from cheese and butter. Meat and meat products are the next major animal source of SFA in the diet, with only minor contributions from eggs and fish.

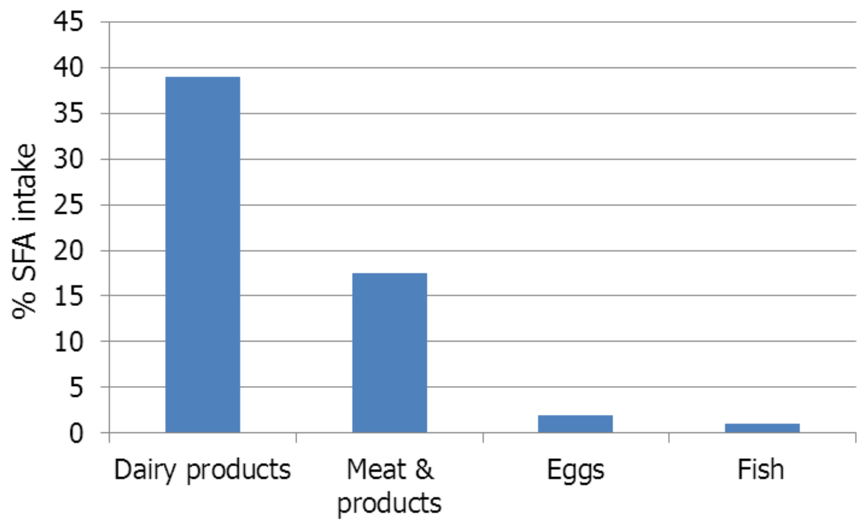


Figure 4 Contribution of animal products to SFA intake (Hulshof *et al.*, 1999)

Effect of type of SFA on cholesterol

Although SFA are generally considered as a group and recommendations are for a reduction in total SFA, data indicate that not all SFA are 'bad' in terms of their effect on plasma cholesterol level and associated risk of CVD.

Mensink *et al*. (2003) evaluated the effect of the three SFA most associated with elevated total plasma cholesterol levels (lauric acid, C12:0; myristic acid, C14:0; and palmitic acid, C16:0) along with stearic acid (C18:0) (generally considered neutral in terms of effects on plasma cholesterol) (Figure 5). These data demonstrate that while C12:0, C14:0 and C16:0 increased the level of the artery-clogging 'bad' LDL-cholesterol, the level of 'good' HDL-cholesterol was also increased. This resulted in the ratio of total cholesterol:HDL-cholesterol (considered highly important in estimating risk of CVD) being beneficially reduced with C12:0 and C14:0 and increased only with the C16:0 SFA. Overall, SFA were approximately neutral in their effect on total:HDL-cholesterol, indicating that SFA may not represent as great a risk to CVD as traditionally thought. However, both MUFA and PUFA beneficially reduced this ratio.

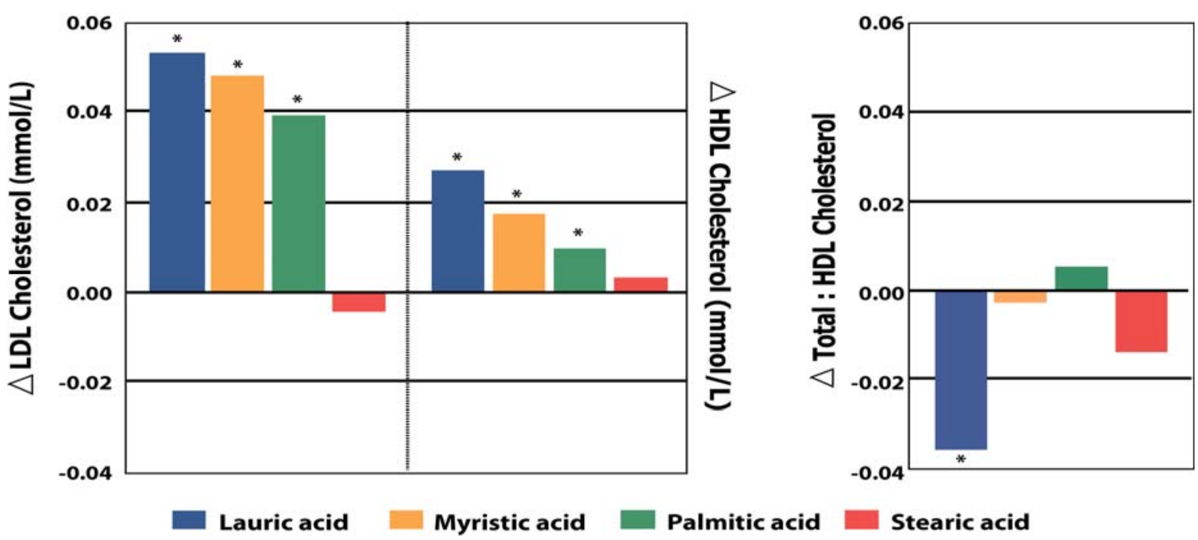


Figure 5 Effect of individual SFA on change in concentration of plasma cholesterol (Mensink *et al*., 2003)

Dietary modification of milk SFA

Up to 50% of the fatty acids in milk are derived directly from dietary sources; this includes around half of the C16:0 and most of the C18 and longer-chain fatty acids. The remainder of the C16:0 along with the shorter chain fatty acids (C4:0 to C14:0) are synthesised *de novo* in the mammary gland. Some fatty acids are also supplied by mobilised body fat during periods of negative energy balance.

Attempts to modify the fatty acid profile of ruminant milk fat by reducing the proportion of SFA and increasing the proportion of USFA represent a challenge to animal nutritionists. Unsaturated fatty acids entering the rumen are extensively (typically 85 to 97% of PUFA) biohydrogenated to SFA by addition of hydrogen atoms to the double bond positions on the fatty acid chain. Hence, regardless of the fatty acid profile of the diet consumed, the predominant fatty acids leaving the rumen for delivery to the mammary gland are saturated C16:0 and C18:0 with only a small proportion of USFA.

Due to the difficulty of delivering USFA post-rumen, considerable research effort has been directed to development of technologies which provide 'protection' of fatty acids from ruminal biohydrogenation. In addition to increasing the bypass of USFA, feeding rumen-protected forms of USFA avoid the production of *trans* fats which can lead to very substantial reductions in milk fat %.

Volac were the first company to use calcium salt technology to provide rumen-protected fatty acids. As discussed in Bulletin (2), Megalac has been used successfully worldwide for nearly 30 years and is an effective method of increasing delivery of USFA to the mammary gland.

Palm oil and Megalac – effect on milk fatty acid profile

Palm oil is commonly used as a fat source for supplementing dairy cows and contains a near-equal balance of SFA and USFA (Figure 6).

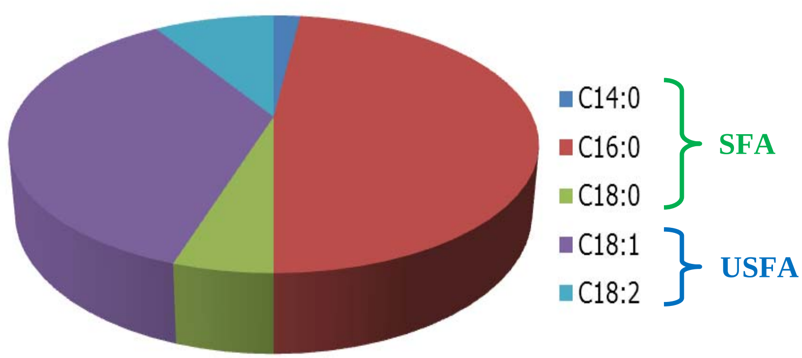


Figure 6 Fatty acid profile of palm oil

Megalac is manufactured from palm fatty acid distillate (PFAD), a derivative of crude palm oil. As almost half the fatty acids in Megalac are USFA in rumen-protected form, inclusion of Megalac in rations can reduce the proportion of SFA in milk fat and increase the proportion of USFA, particularly C18:1 (Table 1). These data also highlight the effect on milk fatty acid profile of supplementing with a highly saturated fat supplement (approximately 85% C16:0 fatty acids); as presented in Table 1, feeding a high-C16 fat supplement increased C16:0 in milk by 3.6%, but had no effect on total SFA due to a reduction in *de novo*-synthesised fatty acids.

Table 1 Effect of Megalac on milk fatty acid profile (% total fatty acids) (University of Reading, 2005)

Fatty acid	Control	Megalac	High-C16 fat
C4:0 - C14:0	30.8	27.5	27.6
C16:0	30.9	30.5	34.5
C18:0	6.7	7.5	6.8
C18:1	13.7	16.2	14.0
C18:2	1.8	1.9	1.7
C18:3	0.32	0.29	0.28
Total SFA	**70.4**	**66.9**	**70.6**
Total MUFA	17.5	19.8	17.7
Total PUFA	2.56	2.71	2.47

A further study evaluated the effect of offering increasing levels of Megalac on milk fatty acid profile (Figure 7). Increasing Megalac from 250 through 500 and 750 g/d progressively reduced *de novo*-synthesised SFA, while increasing C18:1 USFA by up to 17% relative to the control diet.

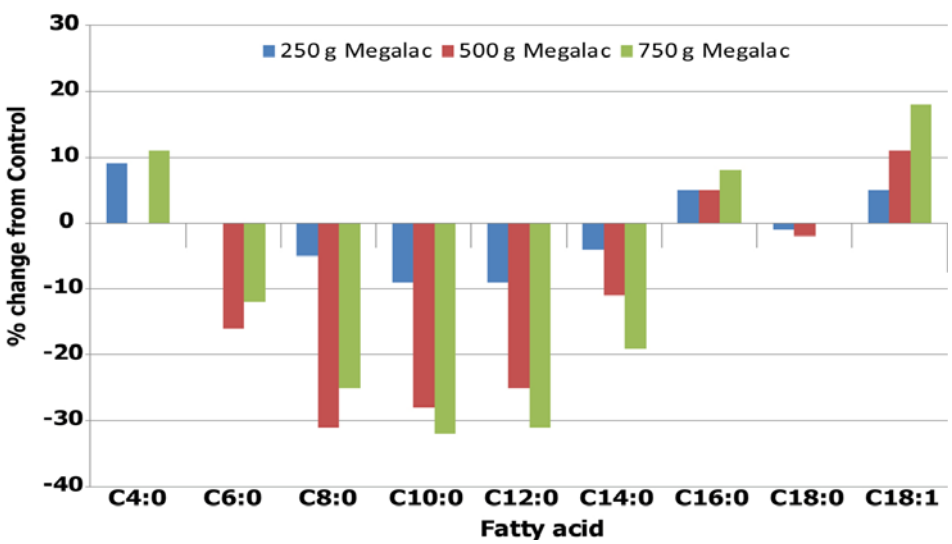


Figure 7 Effect of Megalac supplementation rate on milk fatty acid profile (change relative to control milk) (Palmquist *et al.*, 1993)

Recent work undertaken by Volac at the University of Reading evaluated the effect of feeding a fat supplement containing a high proportion of C18:1 USFA. This study (Kliem *et al.*, 2011) recorded a reduction in SFA from 71% to 52% of total fatty acids and highlights the potential to significantly reduce SFA in milk using specific rumen-protected fatty acids.

Conclusions

A recent public health campaign by the FSA has raised awareness of the potential health risks of eating too much saturated fat. Dairy products, as primary contributors of SFA to the diet are a major target for this campaign, though data indicate a clear difference in the cholesterol-raising potential of individual SFA. Milk and dairy products contain many vital micronutrients which are known to be beneficial to human health and studies have demonstrated cardio-protective and other benefits from milk consumption. Hence, reducing intake of dairy products in an attempt to reduce SFA intake may have a negative effect on human health traits. Indeed, in the US context, Palmquist (2005) concluded that most consumers need not be concerned about the composition of 'normal' milk fat, though modified-fat dairy products would provide wholesome alternatives for those with real or perceived concerns. Nevertheless, level of SFA in milk can be reduced by feeding research-proven sources of protected USFA, including palm oil-based fat supplements such as Megalac.