Table 5.2 Fatty acid composition of milk fat.

Fatty acid	Typical composition[1]	Summer milk fat[2]	Winter milk fat[2]	Summer milk fat, minimum[3]	Summer milk fat, maximum[3]
C4:0	4.1	4.2	4.6	2.93	4.88
C6:0	2.4	2.3	2.7	1.54	2.65
C8:0	1.4	1.3	1.5	0.82	1.71
C10:0	2.9	2.6	3.4	1.77	4.08
C10:1	0.3	—	—	—	—
C12:0	3.5	3.0	4.2	1.99	4.69
C14:0	11.4	9.6	11.6	7.10	12.34
C14:1	—	—	—	0.51	1.04
C15:0	—	1.1	1.1	0.76	1.10
C16:0	23.2	23.3	29.1	24.95	32.08
C16:1	—	1.0	0.7	1.21	1.49
C17:0	—	0.8	0.9	0.41	0.57
C18:0	12.4	11.9	9.5	9.92	15.36
C18:1	25.2	28.1	21.3	21.22[4]	31.59[4]
C18:2	2.6	1.3	1.6	2.29	4.53
C18:3	0.9	1.1	1.4	0.20	0.64
C20:0	—	—	—	0.09	0.13
CLA	—	—	—	0.48[5]	1.00[5]
Others	10.0	—	—		

[1] Mulder and Walstra (1974).
[2] Badings *et al.* (1983). Summer and winter milk fat from The Netherlands.
[3] Kaylegian *et al.* (2009). Summer milk fat from the United States.
[4] C18:1 is a total of all C18:1 isomers reported.
[5] CLA is a total of all CLA isomers reported.

when cows are fed rations. The milk fat from cows on pasture in the summer contains higher amounts of unsaturated fatty acids (Badings *et al.*, 1983; Salamon *et al.*, 2006) and more carotenoids, resulting in a softer milk fat that has deeper yellow colour than milk fat from cows on rations. This is observed by chocolate makers when comparing functional differences between anhydrous milk fat (AMF) from the United States to AMF from New Zealand. Even within the same season the composition of individual fatty acids can vary quite a bit. Kaylegian *et al.* (2009) sampled milk from 45 farms in three regions across the United States in the same summer and reported ranges of C4 from 3.25% to 4.88%, C16 from 24.95% to 32.08% and C18:1 from 18.79% to 25.86% (Table 5.2). Differences in milk composition due to stage of lactation is illustrated by Lynch *et al.* (1992) who reported a change in C4 concentration from 4.5% at the beginning of lactation to 2.5% at the end of lactation and a C16 content that went from 24% to 35% from beginning to end of lactation.

The stereospecific position of fatty acids on the triglyceride molecule has an important relationship to its flavour, crystallisation and melting properties. The large number of fatty acids identified in milk fat yields over 100 000 individual triglycerides that are not well characterised for milk fat (Larsson,1994). In contrast, cocoa butter has a much simpler fatty acid composition and a known triglyceride profile (Longchampt and Hartel, 2004; see Chapter 7). The fatty acids in milk fat are esterified to the triglyceride structure in the mammary gland following a general order that is not random (Kaylegian and Lindsay, 1995; MacGibbon and Taylor, 2006; Parodi, 2004):

- C4 (butyric) and C6 (caproic) are in the sn-3 position.
- C8 (caprylic) is located in the sn-2 and sn-3 positions.
- C10 (capric) is located preferentially in the sn-2 position.
- C12 (lauric) is located preferentially in the sn-2 position.
- C14:0 (myristic) is in the sn-2 position.
- C16:0 (palmitic) is almost equally distributed in the sn-1 and sn-2 positions.
- C18:0 (stearic) is in the sn-1.
- C18:1 (oleic) is in the sn-1 or sn-3 position.

5.2.2.2 Flavour contributions of milk fat

One of the most important functions of milk fat in chocolate is its role in flavour – it directly provides flavour compounds, serves as a flavour precursor and as a flavour carrier. Free fatty acids, lactones, ketones, esters, aldehydes and carbonyls are important compounds from milk fat that contributors to flavour. Flavours derived from milk fat are generated by a number of mechanisms that occur during the manufacture of chocolate, including heating, hydrolysis or lipolysis, dehydration and decarboxylation. Milk fat is delicate and susceptible to deterioration upon rough handling, exposure to light, heat, and oxygen, which can cause undesirable flavours.

Lactones and methyl ketones are thought to be important in the flavour of milk chocolate. These compounds are formed from β-hydroxy fatty acids released from the triglycerides when milk fat is heated.

Although lipolysis is considered to be undesirable in most dairy products, it can be used to an advantage in milk chocolate. Fresh milk contains lipases, which hydrolyse the triglyceride molecules and release fatty acids including butyric, caproic and capric acids. These volatile flavourful fatty acids can impart a "buttery", "creamy" flavour in milk chocolate. The natural milk lipase is normally inactivated during pasteurisation. In some cases, heating applied during some chocolate processes may be sufficient to release these fatty acids. Hydrolysed milk fats have been produced to enhance the buttery flavour of milk chocolate (Campbell and Pavlasek, 1987). The controlled use of lipolysis of milk fat is normally associated with chocolate manufactured in the United States and the reaction is used at lower levels in many European chocolates. The lipolysis reaction needs to be carefully controlled to avoid the cheesy and soapy flavours that are characteristic of a high degree of lipolysis, often referred to as lipolytic rancidity.