term "serum protein" is used when referring to these proteins as they are found in native milk, whereas "whey protein" more accurately reflects the proteins when they have been recovered from the whey stream after cheese making.

The caseins (α_{s1}, α_{s2}, β, κ) are found in milk in the form of an open micelle structure suspended in the serum (aqueous) phase. The casein micelle is made up of small submicelles held together by calcium phosphate bridges. The casein micelles coagulate to form gels, either driven by acidification to the isoelectric point or by enzymatic processes (e.g., the rennet coagulation in cheese making). The serum proteins consist of β-lactoglobulin, α-lactalbumin, immunoglobulins, lactoferrins and other minor proteins. The serum proteins contain a large amount of disulfide bonds that yield a more compact, globular shape than the caseins. The serum proteins denature and unfold at high temperatures, unlike the casein proteins which are stable to heating.

5.2.1.2 Flavour contribution of milk proteins

Milk proteins contribute to the flavour of milk ingredients and chocolate through two mechanisms. The first being the Maillard reaction, which is a reaction between a reducing sugar and amino acids. The milk proteins serve as a source for the amino acids and the naturally occurring lactose in milk is a reducing sugar. The chemistry underlying the Maillard mechanism is extremely complex and a result of many different types of reactions that create desirable flavours in chocolate.

Milk crumb chocolates (see Chapter 6) are characterised by the more pronounced toffee flavours. Analyses have identified multiple components that are characteristic for toffee and malty flavours, among those are maltol, 3-methyl butanal furanones and pyrazines (Kriebardis and Wedzicha, 2005). Milk manufacturers wanting to produce crumb-like milk powders are looking to maximise those profiles during processing. Patents for processing those kinds of flavours have been issued (Hansen *et al.*, 2003). The essence of the patents is the addition of Maillard flavour components, like the Strecker aldehydes, or hydrolysed casein, whey or ketose saccharides to get the process started. Using intense heating of milk or enhancing pH in the milk prior to pasteurisation and drying have been investigated (Skytte, 2006), however few reports on the commercial success for those products are available.

The second mechanism whereby proteins contribute flavour is the breakage of disulfide bonds in the serum proteins during heat-induced denaturation that results in desirable cooked flavour notes in heated milk (Caric, 1994).

5.2.2 Milk fat

Milk fat contributes to flavour and texture and helps inhibits fat bloom in chocolates. Milk fat is found in fluid milk in the form of globules. The globule has a fat core surrounded by a protein and phospholipid membrane that keeps it emulsified in the serum phase. The phospholipids in the globule membrane are mainly lecithin (1% of the milk fat content) and provide emulsifying properties that lower the viscosity in chocolate (Beckett, 2000). Milk ingredients based on native fluid milk, such as cream and milk powders, contain milk fat in globular form. In the processing of concentrated milk fat-based ingredients, such as butter and anhydrous milk fat, the globule structure is broken and the membrane components are removed, leaving the core fat.

5.2.2.1 Milk fat composition

Milk fat has the most complex chemical composition of the edible fats and contains a high proportion of short-chain fatty acids (C4–C8). The core of the milk fat globule is predominately triglycerides, with small amounts of mono- and diglycerides, free fatty acids, sterols and the fat soluble vitamins (Table 5.1; Mulder and Walstra, 1974).

There are approximately 20 fatty acids that make up the majority of the fat content in milk, although over 400 different fatty acids have been identified (Jensen and Newburg, 1995). The typical composition of milk fat that is reported in the literature is shown in Table 5.2 (Mulder and Walstra, 1974). The C4–C14 and some of the C16 fatty acids are synthesised in the mammary gland of the cow (McGuire and Bauman, 2003; Parodi, 2004). The short-chain and odd carbon number (C15, C17) fatty acids are generated by fermentation of feed components (German and Dillard, 2006). The remaining C16:0 and the long-chain fatty acids originate in the diet and from lipolysis of adipose tissue (Parodi, 2004). Milk fat is comprised of fatty acids that are 65–70% saturated, 27–33% monounsaturated and 3.5–5.0% polyunsaturated. About 2–5% of the total fatty acids are *trans*-fatty acids that occur naturally due to bacterial metabolism in the rumen (Parodi, 2004).

The content of the individual fatty acids in milk fat can be greatly influenced by breed, stage of lactation, genetics, animal differences, feed and season. The influence of season is usually correlated with changes in feed – “summer milk fat” often referring to when the cows are on pasture and “winter milk fat” referring to

Table 5.1 Components of milk fat.

Component	Weight (%)
Triglycerides	98.3
Diglycerides	0.3
Monoglycerides	0.1
Free fatty acid	0.1
Phospholipids	0.8
Sterol	0.35
Carotenoid	Trace
Vitamins (mainly A, D and E)	Trace
Flavour compounds	Trace