

Oxidation of milk fat occurs when the unsaturated double bonds in the fatty acid are broken through a variety of mechanisms, including auto-oxidation or by exposure to light, heat and oxygen. The compounds formed as a result of oxidation may be low in concentration and individually undetectable. As the oxidation reactions progress, off-flavour compounds are formed in higher concentrations that are as described as cardboardy and fishy. To avoid the cardboardy flavour sometimes found in chocolate, exposure to oxygen should be avoided during storage by using appropriate packaging materials. This is of concern particularly in white chocolate where the natural anti-oxidants found in non-fat cocoa solids are not present.

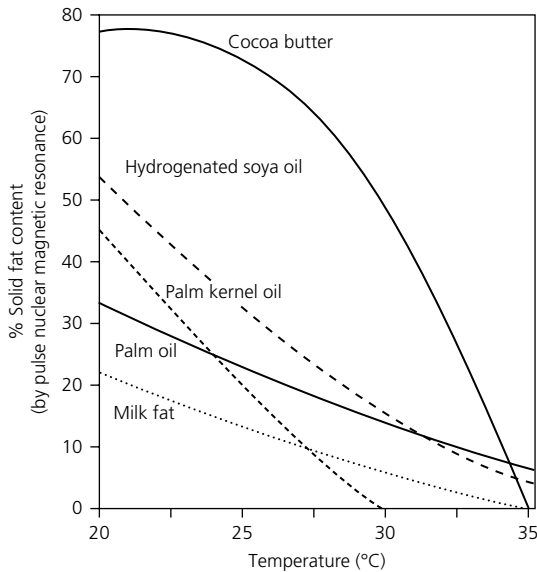
### 5.2.2.3 Interactions of milk fat and cocoa butter

Milk fat is compatible with cocoa butter to a limited extent and is able to become part of the continuous fat phase of chocolate. Milk fat and cocoa butter have different stable crystal forms and, therefore, the two fats will not mix completely in the solid state (see also Chapters 7 and 13). Milk fat alters the temperatures at which the various crystal forms of cocoa butter occur. Milk fat slows the rate of cocoa butter crystallisation in mixtures of cocoa butter and milk fat, and this occurs in chocolate containing mixtures of these two fats (Timms, 2003). Increasing the amount of milk fat added to the blend alters the physical and functional properties of chocolate including hardness, ability to temper and melting point (Barna *et al.*, 1992; Full *et al.*, 1996).

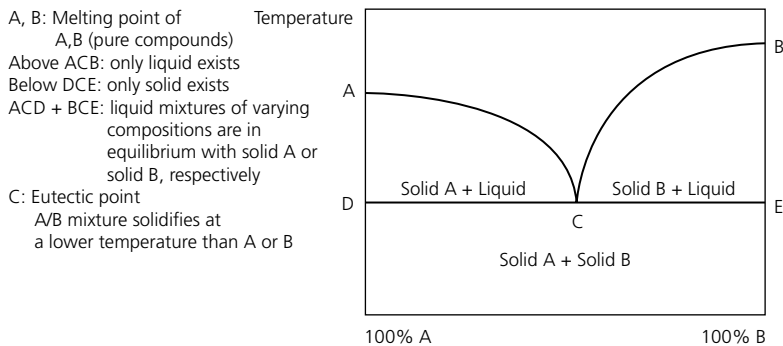
The solid fat content of cocoa butter is much higher at ambient temperatures than most other natural fats, as shown in Figure 5.2. Milk fat is unlike cocoa butter in that it contains numerous different fatty acids, especially short-chain fatty acids. However, the compatibility of milk fat with cocoa butter is not caused by unique milk fat triglycerides, but occurs because the milk fat does not change the polymorphic form of cocoa butter at the typical level of milk fat addition to chocolate. The level of milk fat addition to cocoa butter required to cause changes to the crystal forms of cocoa butter is approximately 50% (Timms, 2003). The incompatibility of milk fat and cocoa butter at levels greater than this is not of practical concern to chocolate manufacturers because the level of addition of milk fat is usually limited to 30% of the total fat. At levels of milk fat addition above 30% of the total fat, chocolate becomes soft because more liquid fat is present at these very high proportions of milk fat. Softer products may be less acceptable to consumers and may bloom more readily if subjected to thermal abuse.

Most commercial milk chocolate products are made with a ratio of milk fat to total fat of between 12 and 32%. A general guideline is that, in order to achieve the desired physical properties of chocolate, a minimum solid fat content of 45% is required. Tempering conditions will need to be optimised to achieve this (Yella Reddy *et al.*, 1996).

Timms (1980) has shown that different portions of milk fat have different effects when mixed with cocoa butter. The low-melting triglycerides in milk fat have the effect of diluting the cocoa butter and hence soften the chocolate



**Figure 5.2** Typical solid fat content profiles of different fats at a range of temperatures.



**Figure 5.3** Phase diagram of a simple binary system (e.g., cocoa butter and milk fat).

because of their lower solid fat contents. The middle-melting triglycerides form a eutectic between cocoa butter and milk fat; that is, the solid fat content of the mixture of the two fats is less at any given temperature than a simple summation of the contributions to the solid fat content of the two components. The formation of a eutectic is shown in the simplified phase diagram in Figure 5.3. The overall effect of adding milk fat to chocolate is softening because of the low- and middle-melting triglycerides.

#### 5.2.2.4 Free and bound milk fat

Milk fat influences the properties of chocolate depending on the form of the fat. It can be added to chocolate via roller-dried or spray-dried whole milk powder (WMP) and through the use of AMF. Spray-dried WMP, in which most of the fat remains bound, is termed a low free fat system. Replacing spray-dried WMP with skim milk powder (SMP) and AMF, so that all of the milk fat is available as