11.9 Factors affecting the flow properties of chocolate

A major reason for being able to measure the viscosity of chocolate is to be able to correct it when production difficulties occur. Some may relate to the yield value rather than the plastic viscosity and vice versa. In order to correct it, it is therefore important to know which factors affect the flow property concerned. Some of these factors are therefore described in the following sections.

11.9.1 Fat content

It is useful to consider the microstructure of chocolate in order to understand how it flows. This is illustrated schematically in Figure 11.14. It is the liquid fat (both cocoa butter and milk fat) that enables the chocolate to flow. In weight terms it constitutes about one-third of the chocolate, but in volume terms (because fat has a lower density) it is almost one-half. As the fat content increases the distance between the solid particles increases so the viscosity drops. Some of the fat is bound by and within the particles (see Chapters 3 and 5) and so does not aid the flow. If a chocolate is too thick, the further grinding of the cocoa liquor or the use of an alternative milk powder source should be considered.

It is the free fat that enables the chocolate to flow and if the total fat content is low (e.g. about 25%) then the proportional increase in free fat content of an extra 1% of cocoa butter is going to be a lot greater than for one with 35% fat content. This means that the effect on viscosity of additional cocoa butter is much greater at lower fat contents and becomes very small indeed above 35%, as illustrated in Figure 11.15 (Chevalley, 1999). The yield value arises mainly from the inter-particle interactions and is less affected than the viscosity value by the addition of fat. Where the yield value is incorrect, other such factors should be investigated.

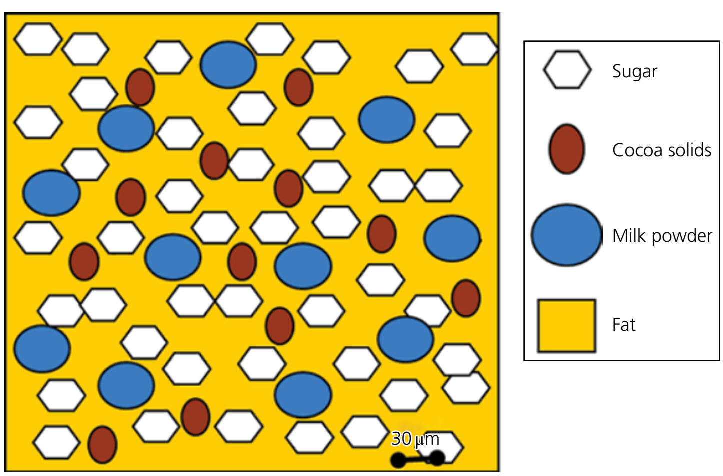

Figure 11.14 Schematic representation of the solid particles and fat within a milk chocolate.

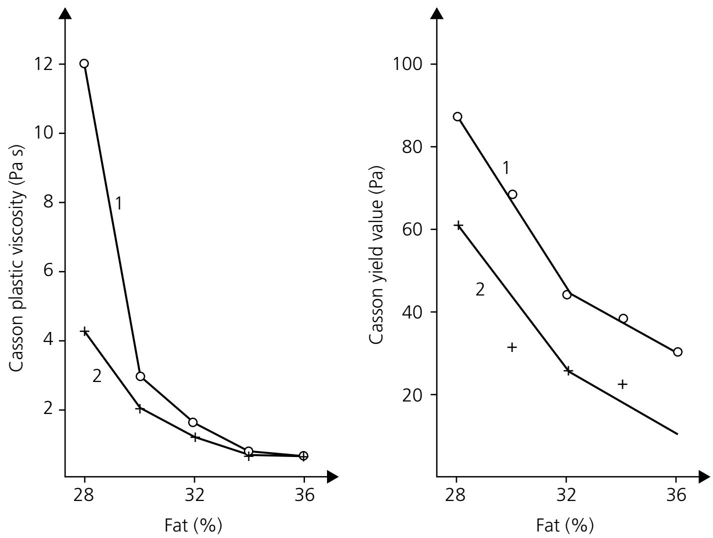

Figure 11.15 Influence of fat content on the Casson viscosity parameters in two milk chocolates with 0.25% lecithin: (1) fine chocolate with 5.7% particles > 20 µm, (2) coarse chocolate with 16% particles > 20 µm (Chevalley, 1999).

All the factors tend to be interrelated. In Figure 11.15 it can be seen that the magnitude of the effect of adding extra fat depends upon the particle size.

11.9.2 Particle size distribution

It is necessary to grind all the sugar and other solid particles below about 30 µm to avoid the chocolate tasting gritty. Granulated sugar has a diameter of about 1 mm (0.04 in) so must be broken many times during the chocolate production. Each time it is broken new surfaces are created, which have to be coated with fat (Figure 11.14), so in general the finer the chocolate the higher the viscosity. Particle size, like viscosity, is not a single parameter but a distribution, which can be measured for example using laser light scattering devices (Chapter 24). This type of instrument is able to show the distribution from sub-micron to above a millimetre. The percentage of larger particles is required to determine the textural roughness of the chocolate. Another parameter that the instrument calculates is the specific surface area, which relates to the surface area of solid particles which must be coated with fat.

As the chocolate is ground finer, there are more particles to interact so the yield value is increased. In practice the effect upon the yield value is much greater than for the plastic viscosity (Figure 11.16; Chevalley, 1999). The yield value normally correlates with the measured specific surface area. This is not the case for the Casson plastic viscosity, however, where at very large particle sizes the plastic viscosity can indeed increase again. This may be due to increasing amounts of bound fat or to how the solid particles pack themselves together.