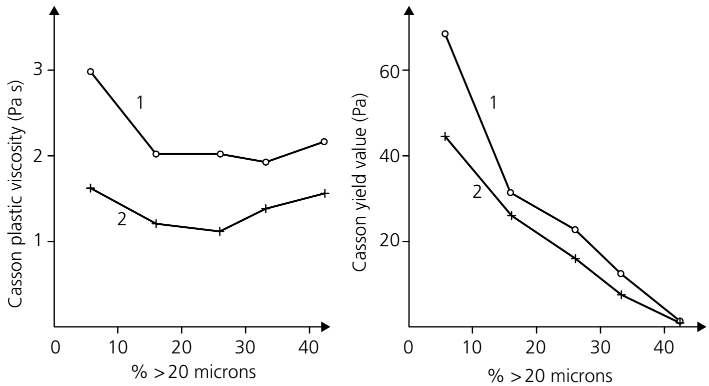

Figure 11.16 Influence of particle fineness on the Casson viscosity parameters in two milk chocolates with 0.25% lecithin: (1) 30% fat, (2) 32% fat (Chevalley, 1999).

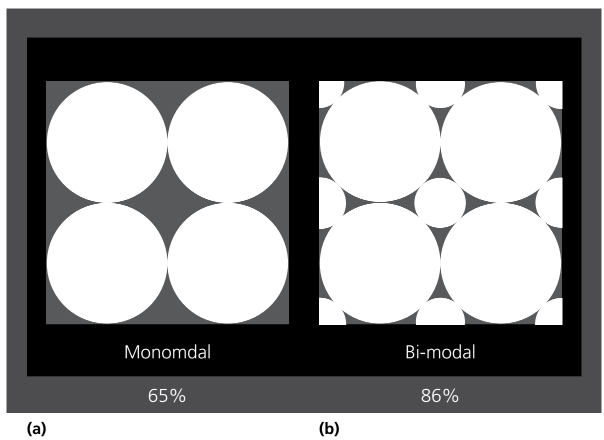

Figure 11.17 Illustration of the packing of spheres that are: (a) all the same size, (b) two different sizes.

If spherical particles all of a similar size are packed together, a lot of space will remain between them, which must be filled with fat or smaller particles (Figure 11.17). In the extreme of having a lot of larger particles or chocolates with very few very fine ones, further grinding will reduce the viscosity. This is however very unusual.

Where an industrial chocolate is found to have a very high yield value, but the plastic viscosity is correct or only slightly high, then the particle size should be investigated as it is possible that the grinding procedure is producing an excessive proportion of fine particles. A high yield value can be counteracted by the use of a surface active agent.

11.9.3 Surface active agents (emulsifiers)

Although it is necessary to coat sugar particles with fat, this is not always easy as the sugar surface is lipophobic, that is it tries to repel the fat. To smoothly combine sugar and fat and thus enable the mass to flow, surface active agents, normally

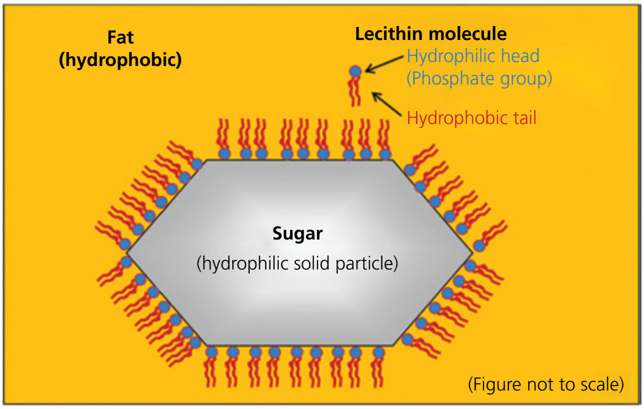

Figure 11.18 Schematic diagram of lecithin molecules around a sugar particle.

known as emulsifiers, are added to the formulation. These amphiphilic molecules adsorb with their hydrophilic (water liking) part onto the sugar surface and the lipophilic (fat-liking) end reaches into the fat separating individual sugar particles (see Figure 11.18). This prevents the formation of sugar aggregates with entrapped fat that is then not available to contribute to the flow properties. Emulsifiers may act on the other particulate ingredients in chocolate although they are understood to predominantly adsorb onto the sugar. The most common emulsifier is lecithin, which has been used in chocolate since 1930. It is naturally occurring, often produced from soya. Soya lecithin aids the flow properties to such an extent that, for additions of up to about 0.3%, it has an effect equivalent to 10 times this weight of cocoa butter. As with cocoa butter additions, the higher the viscosity, the more effective is the addition of the emulsifier (see Figure 11.19). Unlike cocoa butter however, further additions of lecithin can cause the yield value to increase. This may be due to lecithin particles attaching themselves to each other and forming new particles called micelles, or due to the lipophilic ends attaching themselves to the lipophilic ends of a second layer of lecithin and reducing its effectiveness. The point at which this occurs depends upon the surface area of the solid particles being coated. A fine chocolate with high sugar content can therefore tolerate a higher lecithin level than a coarse one or one with lower sugar content. In addition it will depend upon the type of lecithin used.

What is termed lecithin is in fact a mixture of phospholipids, glycolipids, triglycerides, carbohydrates, some water, sterols and free fatty acids. The phospholipids are the predominant amphiphilic compounds and lecithin can vary in the amount and composition of phospholipid present. To optimise industrial chocolate flow, it may be beneficial to use a standardised fractionated lecithin (van Nieuwenhuyzen and Tomas, 2008). The phosphatidylcholine part of lecithin has been shown to be particularly effective in reducing the plastic viscosity of some dark chocolates (van Nieuwenhuyzen, 1997), whereas other fractions are less effective than standard lecithin in reducing the yield value.