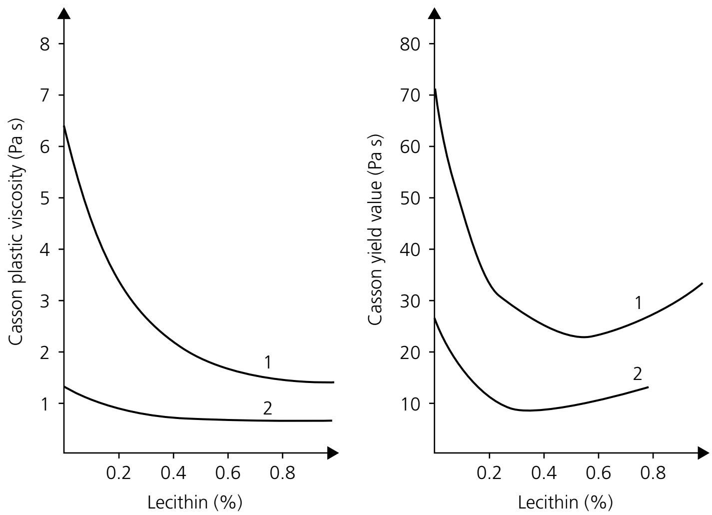

Figure 11.19 Influence of soya lecithin addition on the Casson viscosity parameters in two dark chocolates: (1) 33.5% fat, 1.1% moisture; (2) 39.5% fat, 0.8% moisture. Source: Finke (1965). Reproduced with permission of Springer.

An investigation into the impact of the individual phospholipids and binary mixtures on the rheology behaviour of a chocolate model (sugar in oil suspensions at 0.31 solid volume fraction) has shown that, at low concentration, binary mixtures are more efficient in reducing yield stress than the individual phospholipids (Arnold *et al.*, 2014). The authors also assessed the adhesive interactions between sugar surfaces using atomic force microscopy and correlated these with the rheology of the suspensions.

In addition to lecithin, other surface-active agents have been developed for chocolate. One of the most widely used is the synthetic lecithin YN. It is obtained from partially hardened rapeseed oil after glycerolysis, phosphorylation and neutralisation. YN is more consistent in composition than soya lecithin; its flavour is bland and neutral; its efficiency is said to be greater than that of soya lecithin and, at levels above 0.3%, no thickening occurs. When compared with soya lecithin, YN can sometimes have a stronger effect on $\tau_c\alpha$ than on $\eta_c\alpha$ (see Table 11.1). Concern about genetically modified soya has led to increased interest in YN and lecithin produced from other crops such as sunflower.

Another widely used emulsifier is polyglycerol polyricinoleate (PGPR), sometimes known as Admul-WOL. PGPR has the ability to strongly reduce or even cancel the yield value of chocolate (Table 11.1). This useful property is exploited by the confectioner in such applications as the moulding of Easter egg shells and also for correcting the viscosity of a chocolate that has too many fine particles, or indeed if too much lecithin has been added. A combination of lecithin and PGPR can in fact produce good flow properties, especially in low-fat chocolates. It is possible to purchase this combination as a mixture.

Table 11.1 Flow characteristics of plain chocolate with added emulsifiers at 50 °C.
Source: Harris (1968). Reproduced by permission of the Society of Chemical Industry.

Addition	Casson plastic viscosity (Pa s)	Casson yield value (Pa)
0.3% soya lecithin	0.6	9.2
0.3% YN	1.03	3.0
0.3% sucrose dipalmitate	0.9	16.6
0.3% PGPR	3.25	2.5
0.8% PGPR	2.0	0

Other emulsifiers include citrem, sorbitan tristearate, sucrose esters and calcium-stearoyl lactoyl lactate. Citrem (citric acid ester) has the properties of the lecithin/PGPR combination, whereas sorbitan tristearate is an emulsifier which is used to reduce bloom formation in vegetable fat chocolates rather than to control viscosity.

Emulsifiers sometimes affect the tempering of chocolate, which in turn affects the flow properties of the tempered chocolate (Dhonsi and Stapley, 2006; Radujko *et al.*, 2011; Hartel 2013). The effect of the emulsifier on chocolate flow is normally evaluated on un-tempered chocolate, as in Figure 11.19, but it is useful to check the results on tempered chocolate. It should also be noted that over-tempering thickens chocolate and can cause a low viscosity chocolate to become unusable.

The stage in the process at which the emulsifier is added is a very important factor, for example lecithin added towards the end of conching reduces viscosity by a greater amount than when exactly the same amount is added at the start. The reason for this is that, as the action of lecithin is a surface effect, if it is added to the mass too early, some of it may (by prolonged mixing and grinding) be absorbed into the cocoa particle, thus reducing its efficiency (Weyland, 2008). It is also known that exposure to relatively high temperatures for long times reduces lecithin performance. In addition it can reduce the work input provided by the conche.

11.9.4 Conching

In addition to the time of addition of the fat and emulsifier, the time and intensity of the conching have a big effect on the final chocolate viscosity. The longer a chocolate is conched normally the thinner a chocolate becomes. However with increased time the lowering of viscosity becomes less significant or economic. The intensity governs the rate at which the solid particles are coated with fat. This is normally governed by the conche design but can be helped by changing the amount of material in a conche and the time and order in which the fats and emulsifiers are added. A low intensity conche will never produce as thin a chocolate as a high intensity one however long it is operated. As noted earlier