6.5 Sugar crystallisation during crumb manufacture

The state of crystallisation of the sugars in the finished crumb is very important. The ultimate aim is to crystallise both the sucrose and lactose as fully as possible. The benefits of a highly crystalline crumb are:

- It is less sticky and hygroscopic, so is more stable when stored and easier to handle.
- Very little fat is trapped in amorphous glassy sugar so less fat needs to be used to make the correct finished chocolate viscosity.
- The finished chocolate dissolves more readily in the mouth, giving a cleaner and less sticky mouth feel.

The amount of fat bound up within the sugar varies according to crumb type. This is demonstrated in Table 6.2. Total fat in a recipe can be measured by nuclear magnetic resonance (see Chapter 24). Solvent extraction, however, will not dissolve fat which is trapped in amorphous sugar regions. Large differences can be seen from different crumb types. The rework crumb contains a lot of bound fat because there are significant quantities of glucose syrup in the recipe inhibiting sucrose crystallisation. The difference between the Irish and United Kingdom crumbs can be attributed to the higher processing temperature of the former crumb which slows down the crystallisation rate.

Whether sugars crystallise or not is largely dependent on the temperature conditions during the latter part of the process (Ergun *et al.*, 2009; Mohos, 2011). This can be summarised by reference to Figure 6.6, which shows the relationship of temperature and sugar concentration on crystallisation (Schmidt, 2012).

- The upper continuous line defines the maximum solubility of sucrose in water at different temperatures. When processing above this line, all sucrose will be in solution and no crystallisation can occur.
- The lower continuous line refers to the glass transition temperature for sucrose in water. Below this line the viscosity is so high that though there are many crystal nuclei they are unable to grow.
- Optimal crystallisation occurs roughly half way between these two lines as outlined in the diagram.
- To arrive in this area we need to evaporate moisture from the mixture. This can be done by boiling under atmospheric conditions. In this case we would need to achieve a solids content of nearly 97% to reach the optimal crystallisation

Table 6.2 Extracted and bound fat within different types of crumb.

Recipe	Total fat (%)	Extracted fat (%)	% of fat bound within the crumb
Plain chocolate	27.0	27.0	0.0
Crumb milk chocolate	30.0	29.5	1.7
UK crumb	16.2	15.6	3.7
Irish crumb	16.0	12.9	19.4
Rework crumb	24.0	9.6	60.0

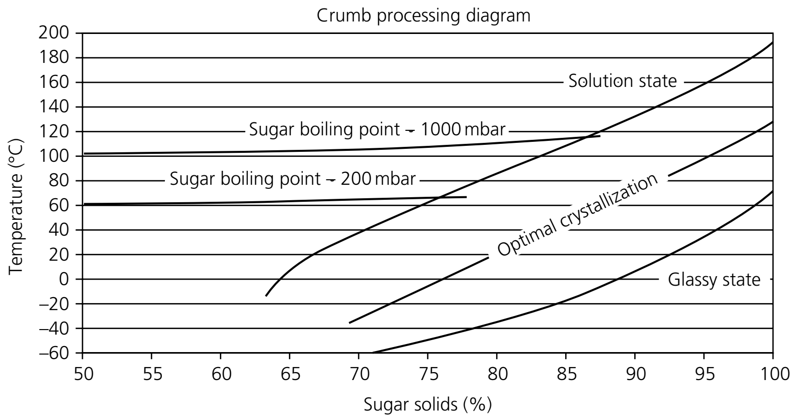

Figure 6.6 The effect of temperature and sugar concentration on crystallisation.

temperature. Product viscosity is then very high and considerable shear is needed to achieve high levels of crystallinity. In addition the high process temperature will lead to high flavour development.

- Alternatively, it is possible to evaporate under reduced pressure. If this is around 200 mbar, optimal crystallisation begins at around 90% solids, at a temperature of about 80 °C (176 °F) and with a manageable product viscosity. Crumb flavour is less pronounced at this temperature and high levels of sucrose crystallinity can be routinely achieved.

To achieve high sugar crystallinity it is helpful also to apply shear while the product is in the optimal region of the processing window just described. In the original batch oven process, this was achieved by mixing the sweetened condensed milk and the cocoa liquor in a melangeur pan (see Chapter 1) until the correct crystal size was achieved according to optical microscope measurements. Modern continuous crumb processes are careful to build in shear steps before the crumb paste becomes too viscous.

Many early batch crumb processes did not incorporate shear during the final production stages and the product was highly amorphous (glassy). This produced a highly viscous chocolate when it was freshly made, so the crumb was "matured" in hessian sacks in a humid atmosphere for several months before it was used. This enabled the glassy particles to absorb moisture and become crystalline, before ejecting the moisture again. "Matured" crumb produced chocolate with a similar viscosity to crystalline crumb, but had the big disadvantage of requiring long storage periods.

6.6 The structure of chocolate crumb

The way the crumb ingredients bind together on the micro and macro scale is crucial to the crumb's behaviour in subsequent handling and chocolate processing. This section deals with this topic.