one-half of all the fat conserved at the refining step is saved during conching (Kuster, 1991), that is if you reduce the fat at refining by 1%, you only need to put 0.5% into the mass at the end of conching to obtain the same viscosity. Bolenz and Manske (2013) demonstrated the influence of fat content on the particle size distribution and flow properties of milk chocolate refined in either a roll refiner or ball mill. As stated earlier, a material's tendency to agglomerate rises with smaller particle size and moisture content. Refining a very low-fat mixture, especially under humid conditions, can result in particle agglomerates exiting the roll refiner.

The recent trend toward high cocoa content chocolates presents a challenge to traditional roll refining, since for example a recipe containing 70% cocoa mass would contain about 38–39% fat, too much for efficient roll refining. Two alternatives are available: use of a stirred-media (ball) mill or roll refining only a portion of the cocoa mass with the remaining portion added during conching, preferably after a period of dry conching. Ziegleder (2006) has demonstrated that, for the first of these alternatives, ball milling, it is advisable to withhold some of the added cocoa butter, if any, until later in the milling process.

For accurate particle size control it is necessary to produce consistent and uniform feed material, which can be produced by intense mixing prior to refining, or perhaps even better by the two-stage refining process. The two-stage refining system employs a two-roll pre-refiner to size the feed material for efficient five-roll operation. Separate sugar pulverisation (as was previously needed with a single-stage refining process) can be eliminated with two-stage refining, allowing for use of granulated sugar in the chocolate formulation. This improves mixing and permits refining at lower fat content. Ideally, the particle size exiting the pre-refiner should be slightly smaller than the feed gap of the five-roll machine and, in practice, no more than 20% greater than the first five-roll gap (Kuster, 1991). Among the potential benefits of two-stage refining are a 10–25% increase in the throughput capacity of the five-roll machine and savings in cocoa butter needed to standardise the flow properties. The latter results from a reduction in the proportion of very fine particles.

At least one roll refiner manufacturer has automated the milling process by incorporating online measurement of film thickness at the final roll (R5). The deviation of the measured value from a set point value is used to control the mass throughput by changing the gap setting at R2, as previously described. In addition, automated feed level control and dry running protection are also available (rolls become damaged very quickly if there is no material between them).

Refiner roll wear depends on the correct adjustment of the hydraulic roll stack pressure and the product recipe. The major contributors to roll wear are shell and silicates (sand) present in the cocoa mass, so efficient cleaning and winnowing of cocoa beans are very important. In general, the greater the cocoa mass content of the chocolate, the lower the anticipated service life of the rolls.

Wear increases substantially with the silicate content of the cocoa mass, the final degree of fineness of the chocolate and the contaminating shell content. The same could be expected to hold true for other chocolate refining devices.

9.5.2 Crumb chocolate

Refining of chocolate crumb is easier, that is it requires less power and results in less wear, provided that the crystallisation of sugars during the crumb-making process is adequately controlled, since only loose agglomerates of sugar, milk solids and cocoa solids are being broken. If the agglomerates are less than about 125 μm (0.005 in) then single-stage refining may be appropriate, otherwise two-stage refining may be necessary. Because fewer primary sugar crystals are being fractured, fewer fines (<5 μm) are present and particles are less jagged in refined crumb chocolate as compared with the milk powder process.

9.5.3 Sugar substitutes

Here we are principally talking about the growing number of alternatives to sucrose. Bouzas and Brown (1995) and Chapter 4 have reviewed the physical and chemical characteristics of sugars and sugar substitutes in relation to their usefulness in chocolate, so we will restrict our discussion to the grinding of these materials. Fructose is particularly difficult to grind due to its hygroscopic nature (Niediek, 1994). Sugars that form crystal hydrates, for example glucose (dextrose) and maltose, may lose their water of hydration during roll refining, causing complications downstream (Hogenbirk, 1985). Anhydrous forms of glucose and maltose can be ground without difficulty, as can anhydrous or crystalline lactose monohydrate. Sucrose-free chocolates containing lactitol monohydrate must be roll refined at temperatures below 60 °C (140 °F), while those containing anhydrous lactitol or maltitol can be refined under standard conditions (Olinger, 1994). Isomalt-, mannitol-, sorbitol- and xylitol-sweetened chocolates should probably be refined at relatively low temperatures (<40 °C; <104 °F) and under dryer processing room conditions than sucrose-sweetened chocolates. Bulking agents like amorphous polydextrose can be roll refined, exhibiting brittle fracture below their glass transition temperature, but the fibrous structure of microcrystalline cellulose makes it difficult to grind.

9.5.4 The refiner-conche

The refiner-conche consists of a drum with a serrated internal surface. Particles are broken as they are forced between spring-loaded scrapers and the interior drum surface (see Figure 10.27 in Chapter 10). Initially, this type of machine reduces particle size rapidly but, as the mass becomes liquid, the few remaining large particles have a lower probability of being caught in the grinding gap and so the resultant particle size distributions are wide (Beckett, 1994). This can be improved by combining these systems with either a ball mill or roll refiner. Higher fat content during grinding is necessary since ball mills require a liquid feed.