2 Freeing of gases from the mass;
3 Formation of electrostatically charged oxygen and ozone, thus causing some oxidation;
4 Homogenisation of the ingredients.

It is now known that ultrasound can create free radicals, which promote oxidation and other reactions that may be beneficial to some types of chocolate but detrimental to others. For example it is said that, whereas oxidation may assist flavour development in plain chocolates, it may give rise to an unpleasant taste in milk chocolates. Initially, in fact, treatment with ultrasound was more successful with plain or bitter chocolate, where it was generally found to reduce conching time from about 72 to 36 h. Mosimann (1963) in particular developed it for use with all types of chocolate, so that it could be used as part of a manufacturing process which required no conching at all (Figure 15.1). He concluded that previous workers were using too long a treatment time (up to 120 s) and limited his processing period to a fraction of a second. Mosimann found that ultrasonics accentuated flavours, including undesirable ones, so it was necessary to ensure that the latter were not present in the feed material. In addition some de-aeration was needed for milk chocolates. For these, the exposure time was extremely critical, with longer times giving a deterioration of flavour and an increase in astringency. The ability of ultrasound to generate free radicals decreases with increasing frequency and therefore the frequency used is crucial: 800 kHz was found to heat the chocolate and give inferior results; and, although the most suitable

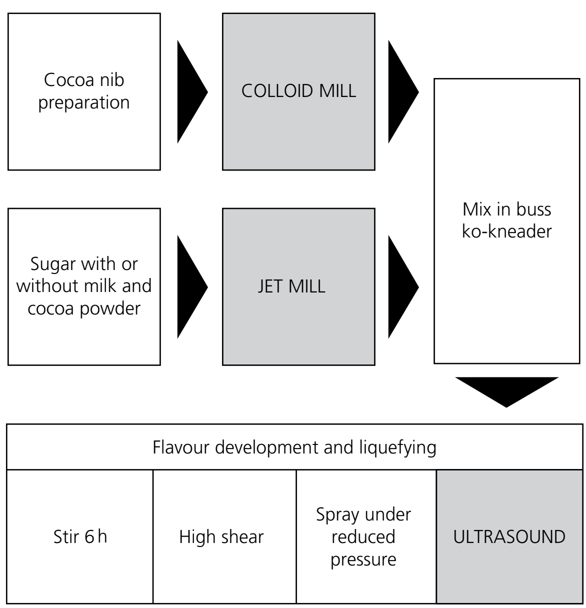

Figure 15.1 The Mosimann process for chocolate making.

frequency was found to vary with the chocolate recipe, it was normally in the region of 20 kHz.

Ultrasound has also been shown to improve the texture of the final product and make it less sticky in the mouth. This may be related to the fact that it aids the tempering of chocolate. Roberts at the Leatherhead Food RA in the United Kingdom used ultrasound in the 1980s to promote the formation of specific polymorphic forms, whose type depended upon the temperature used. He also found that tempering, particularly of plain chocolate, was improved. Milk recipes were less affected, probably because of the influence of the milk fat.

This has been subsequently developed by Kraft Jacobs Suchard R&D, Inc. (1997), who describe work in which ultrasound is applied in order to retard fat bloom in fat-based confectionery masses. The chocolate is cooled to a temperature of at least 3 °C below the melting point of the required crystalline state and pulses of ultrasound are then applied. The pulse lengths and intervals can vary over a wide range, but preferred values are said to be from 0.5 to 4 or 5 s. Similarly, although a wide range of ultrasound frequencies can be used, the range 20–100 kHz appears to be the most effective. The use of ultrasound is said to make the tempering process more robust and to give products with optimal contraction, gloss and snap.

Ultrasound can also be used to determine the amount of crystalline fat within chocolate at different temperatures, that is the solid fat index. Povey (1997) has shown that this can be done by cooling the fat or chocolate to 0 °C (32 °F) before grinding it into a powder which is smaller than the wavelength of sound. The powder is then dispersed in a mineral oil at a fraction of 20% w/w and the temperature increased to the range needed for the measurements. The amount of solid fat present can be calculated from the velocity of the ultrasound through this mixture. The use of ultrasound to measure chocolate temper online was unsuccessful however, as the signal from air bubbles within the chocolate was much greater than that from the crystallising fat (Anon., 2002).

15.3 High shear/low temperature crystalliser

High shear is considered to be of critical importance in rapidly tempering chocolate (see Chapter 13) and Ziegleder (1985) demonstrated that cocoa butter could be tempered in 30 s at very high shear rates. This is impractical in standard temperers because the heat generated cannot be removed and raises the temperature above the melting point of the fat. This is illustrated in Figure 15.2 (Windhab, 1995) which plots the crystal volume fraction of dark chocolate against the rotational speed of a crystalliser. This machine operates by shearing