3 The improved flow at the higher temperature gives better weight control.
4 A "mature" chocolate with stable nuclei is not easily affected by adverse conditions, such as a high ambient temperature and varying centre temperatures.
5 A large masse of "well seeded" chocolate is held at a high temperature but, being under the melting point of the stable nuclei and being well agitated, remains very stable over long periods of time.
6 The high-temperature coating contains only stable crystals and, with correct cooling, good colour and gloss characteristics will be found.
7 Better shape, for example good bases, are a byproduct of the thinner chocolate produced.
8 A harder, more heat-resistant chocolate is produced, which gives a longer shelf life.
9 Better contraction is obtained in moulding plants.
10 The better hardness and heat resistance results in fewer finger-marks during packing, or fewer wrapping machine problems and down time.

13.5.5 "Recipe factors" influencing tempering quality

Chocolate recipes have changed over recent years particularly with respect substitute fats, viscosity-reducing agents and other additives. Changing the recipe can have an effect on the tempering procedure required, as ingredients may affect the crystal type, shape and rate of formation. For example milk chocolate has a proportion of animal fat (butter), which contains a wide spectrum of low-melting triglycerides. When mixed with cocoa butter this gives a type of "eutectic effect" due to mixed crystals or co-crystallisation. This is useful on one hand (bloom-resistant) and detrimental on the other (lower melting point, softer, slower in tempering and set in a cooler). Mixed or co-crystallisation of cocoa butter with milk fat lowers the melting point of the mixture and hence the temperature to "strike seed". Therefore in conventional tempering more time is necessary to create mature crystal growth (see Chapter 7).

A group of additives generally influencing the crystallisation behaviour of the fat phase are the emulsifiers used in chocolate manufacturing. According to their molecular nature, emulsifiers interact with the surfaces of solid particles as well as with fat crystal interfaces, thus slowing down crystallisation kinetics. This normally means that residence time under crystallisation conditions must be increased.

13.6 Types of tempering machine

13.6.1 Chocolate tempering kettles

Kettle tempering has been used in batch form for very many years, but is no longer seen in modern large-scale chocolate manufacture, although it is sometimes used by small confectioners. However due to its exemplary role, the stirred

vessel type of reactor with its pronounced back-mixing properties is still of interest for comparison with other temperers. When it has good wall-scraping and radial/axial mixing rotor/stator elements, it is an almost-ideal homogenising crystalliser, although a rather long residence time is required.

The kettle is basically a stirred tank whose temperature can be controlled within the appropriate range. It is even possible to adapt kettles to work continuously, by metering chocolates in at the base and overflowing out at the top or vice versa. Additional control can be gained by feeding into a second kettle, once again in at the top and metering the chocolate out at the base. The "time period" is determined by the volume of the kettles and the volume flow rate. It can have major advantages over some other types of temperer, probably the most important being the maturity "time period", which can be from one to two hours, resulting in a high temperature usage chocolate. Further advantages are as follows:

1 Simplicity of all mechanical parts.
2 A simple, easily maintained agitator.
3 Bearings are mounted outside the product contact area, hence do not have the wear or contamination problems associated with pressurised systems.
4 There is no pressure in the equipment and thus no seals are required (they are, however, advisable in order to retain the lubrication oil).
5 Kettles are easy to drain and clean (and can be seen to be clean), which is a prime consideration when changing different colours of chocolate or non-compatible coatings.
6 Particulate ingredients can be added (nuts, raisins, crystals of sugar) at a suitable point, provided the exit pump is slow-running with a large swept volume designed for particulate matter (see Chapter 12; in fact chocolate kettle tempering embodies most of the criteria needed for high quality tempering).

Major disadvantages are a longer start-up time and a greater floor space requirement, when compared with vertical tempering machines. The trend for modern continuous tempering machines during the past two decades has gone towards speeding up crystallisation kinetics by applying higher shear rates and also slightly lower cooling temperatures in order to achieve higher throughput rates. Consequently there tend to be shorter residence times. It is certainly a challenge to the manufacturers of tempering machines to try to match the good mixing homogeneity and "maturation" capability achievable in kettle type units and this has not always been met with some designs of temperers.

13.6.2 Types of continuous industrial tempering machines

This section describes examples of some of the different types of tempering machines that are available (Nelson, 1999). Some older forms of temperers are included to show how different developments have taken place. It is not intended to give a complete market overview of existing tempering machines.