

is dependent on the conching intensity (Ziegleder *et al.*, 2003, 2005). The main factors affecting the flavour change were found to be the dry conching time, total energy/average power, type and rotation speed of shafts, starting fat level, viscosity of chocolate mass, temperature, ventilation, humidity and particle size distribution (Ziegleder *et al.*, 2005; Beckett, 2006; Müntener, 2010). It seems plausible that high particle friction and shear forces facilitate the diffusion and transfer of flavour volatiles. After equal conching times, a modern conche provided a significant higher conching degree and better sensory results than a traditional long-conche (Balimann *et al.*, 2007). This mechanism of flavour redistribution during conching has been found to apply to both milk and plain chocolates. But in the special case of milk chocolate some caramelisation of lactose may occur, depending on the conching conditions.

8.6 Dark chocolate and milk chocolate

8.6.1 Dark chocolate flavour

Owing to their higher proportion of cocoa mass, dark chocolates have a more intense and bitter taste in comparison to milk chocolate. Dark chocolate may show significant variations with respect to sour, bitter, astringent, chocolate, nutty, smoky and burnt flavours (Jinap *et al.*, 2005). There are obvious differences in the flavour of cocoa beans according to where they were grown in the world. The Criollo- and Trinitario-based cocoa varieties are generally known to produce a fine chocolate flavour, often described as a mild nutty and a full flavour, respectively, and are considered “fine grade” cocoas. The “bulk cocoas”, which make up the vast majority of the world’s production, are from Forastero varieties (see Chapter 2). Although they are of good quality and have strong flavour characters, they have less fine chocolate notes when compared to the Criollo type (Cook and Meursing, 1982; Afoakwa *et al.*, 2008; Afoakwa, 2010). This is very pronounced with the so-called “origin chocolates”, which contain cocoa mass of only one defined country of origin. As an example, a plain Arriba chocolate will have the typical taste of the mild, floral and earthy notes of Arriba cocoa. Some consumers prefer premium chocolates with high cocoa content, and dark chocolates with about 70% of cocoa and a high portion of flavour cocoa have a small but constant market. These chocolates need specific manufacturing techniques, as their high fat level, due to the high portion of cocoa mass and cocoa butter, causes difficulties during roller refining. They may be produced by the five-roller refining of a chocolate mixture with a reduced portion of the cocoa mass and later addition of the remaining cocoa mass during conching. Alternatively, cocoa powder can be used in the recipe, or the chocolate mixture can be processed in a ball mill (Ziegleder and Balimann, 2007).

8.6.2 Milk chocolate flavour

In milk chocolate there is a balance between the cocoa and milk flavours (Beckett, 2006), and in comparison to dark chocolates they are softer due to their portion of lower melting milk fat (see also Chapters 5 and 6). A harsh cocoa hides the milky creamy flavours, but once the cocoa intensity is reduced, the creaminess comes to the fore (Afoakwa, 2010). Whole milk powders as well as skim milk powders in combination with anhydrous milk fat are used in milk chocolates (Beckett, 2006; Bouzas, 2014). Roller dried milk forms platelet-like particles with most of the fat outside. This helps the chocolate flow properties and the temperatures used create a small amount of cooked flavour. Spray-dried milk has spherical particles, and most of the fat is trapped within the particle and so is unable to aid the viscosity of the chocolate. The free fat content of whole milk powder as well as the particle size distribution are critical parameters that have a significant influence on the performance of milk powders in chocolate (Aguilar *et al.*, 1994; Mongia and Ziegler, 2000; Ziegler *et al.*, 2001; Liang and Hartel, 2004). The important flavour compounds in milk chocolate stem from cocoa mass, but some additional volatiles were found in milk chocolate which may be relevant sensorily. For example, several δ -lactones and further volatiles such as 2,3-butandione, 1-octen-3-one and 5-methyl-2-hepten-4-one are present, which obviously stem from milk powder (Schnermann and Schieberle, 1997). The volatile flavour components in different types of dry milk have been investigated (Shiratsuchi *et al.*, 1994; Karagül-Yüceer *et al.*, 2002). In addition, short-chain free fatty acids appear to have some influence on the sensory properties of milk chocolate (Ziegler, 1997). Milk chocolates have shorter shelf life when compared to dark chocolates. Off-flavours, which develop during months of age in milk powder, could subsequently be detected in chocolate made from this milk powder (Bouzas, 2014). In stale milk chocolates an increased level of short-chain free fatty acids and volatile lipid oxidation products, 3,5-octadien-2-ones, were found (Ziegler and Stojacic, 1988). As these compounds are formed under the influence of lipases and lipoxidases, there appears to be a residual enzymatic activity, even though the water activity of milk chocolate is very low.

The chocolate crumb process was developed in the 1930s, when the milk powders had poor keeping properties (Beckett, 2006). There are a number of unique processes for making milk chocolate crumb, all starting with milk, sugar and cocoa mass (Martin, 1987). Briefly, the milk and sugar are mixed and moisture is partially removed. The cocoa mass is then mixed in, followed by a drying process to reach a final moisture content of 0.8–1.5%. The flavour developed during crumb manufacturing utilises the Maillard reaction to produce varying degrees of toasted, cooked or caramelised flavours. Usually, key flavour compounds as furfural, maltol, lactones and methyl-ketones may be generated (Bouzas, 2014). It is interesting to note that the market-leading milk chocolate tablets in the United States, United Kingdom and Australia are based on crumb, showing that the consumer appreciates their distinctive flavour and texture (Wells, 2006).