that of sucrose (Pepper and Olinger, 1988). However, as a monosaccharide, xylitol has a somewhat different sweetening character than sucrose (see also Section 4.10).

Xylitol's excellent characteristic is its prophylactic benefit with respect to dental caries. It inhibits the growth of the cariogenic bacteria *Streptococcus mutans* and other closely related bacteria in the oral cavity (Mäkinen *et al.*, 1989). As the highly publicised Turku studies proved, the progression of caries was arrested in people eating xylitol-containing sweets over a period of 2 years (Scheinin and Mäkinen, 1975). Furthermore, two extensive studies initiated by the World Health Organisation, each encompassing more than 900 school pupils in Hungary and Polynesia over the period 1981–1984, showed that caries progression may be significantly slowed if 15–20 g (0.5–0.7 oz) of xylitol in the form of xylitol containing chocolate and candy is eaten together with a normal, sucrose containing diet (Scheinin *et al.*, 1985; Kandelmann *et al.*, 1988). Chocolates may be manufactured with xylitol without any special processing. However, these have a noticeable cooling effect in the mouth.

4.7.13 Erythritol

Erythritol is a monosaccharide alcohol, which has only four carbon atoms. It occurs naturally in many fruits and vegetables. It is produced industrially by fermentation of glucose with an osmophile yeast.

Erythritol has a very high heat of solution (191.3 J/kg), which results in a strong cooling effect when melted in the mouth. Its sweetening power is about 70% of that of sucrose (Cerestar, 2004). As a monosaccharide with a very low molecular weight, erythritol has different sweetening characteristics from sucrose. This is perceived particularly in chocolates as a "burning, scratchy" aftertaste. Depending upon their lower molecular weight, this is a sensory property of monosaccharides (see Section 4.10).

Erythritol has however very different metabolic properties. It is absorbed very quickly from the small intestine and after absorption, about 80% of the erythritol remains unmetabolized and is excreted unchanged in the urine (Bornet *et al.*, 1996). This is not only the reason for its very low calorific value, but also for its high digestive tolerance. Erythritol has a very low calorific value of only 0.2 kcal/g, a glycaemic response of 0 and is tooth-friendly (Cerestar, 2004). Like xylitol it can significantly reduce the caries bacteria *Streptococcus mutans* (Mäkinen *et al.*, 2005).

Milk chocolates made with erythritol can be conched up to 70 °C (158 °F) and plain chocolates up to 80 °C (176 °F; Bechert and Wastijn, 2002).

4.7.14 Maltitol

The disaccharide alcohol, maltitol is produced by hydrogenation of maltose. Maltitol is non-hygroscopic and is slightly less sweet than sucrose, but sweeter than sorbitol and is suitable for "no sugar added" confectionery items. Although oral lactobacilli may ferment maltitol, it is not fermentable by streptococci and

that is why maltitol is considered a tooth-friendly bulk sweetener (Lichtel, 1985). Because it is an anhydrous sweetener, maltitol can be conched at temperatures up to 80 °C (176 °F; Happel, 1995). In order to compensate for a sweetening power that is slightly inferior to that of sucrose, intense sweeteners are sometimes added to chocolates sweetened with maltitol. In combination with polydextrose, maltitol has been used to produce "low carb" chocolates.

4.7.15 Maltitol syrup

Maltitol syrups are hydrogenated maltose syrups containing maltitol, hydrogenated higher polysaccharides and sorbitol. They are commercially available under different trade names. The product is used for hard-boiled candies and as a crystallisation inhibitor of other sugar alcohols in tooth-friendly confectionery articles. Maltitol syrup cannot be used in chocolates because of its high moisture content. However, it can be used in chocolate fillings.

4.7.16 Isomalt

Standard isomalt is a mixture of equal parts of two disaccharide alcohols. It is produced by means of enzymatic conversion of sucrose to isomaltulose, which is then hydrogenated. One of these two sugar alcohols crystallises with two molecules of water, the other exhibits an anhydrous crystallisation. The total bound water content of the product reaches 5%. Isomalt is non-hygroscopic and about 40% as sweet as sucrose. It is used for the production of tooth-friendly candy and confectionery articles, which are also low or reduced glycaemic index. Isomalt also has prebiotic properties (Gostner *et al.*, 2006). The low sweetening power of isomalt in chocolate can be offset by means of intense sweeteners. Because standard isomalt loses its water of crystallisation at relatively low temperatures, the conching temperature of isomalt chocolates may not be higher than 45 °C (112 °F). Recently isomalt variants for special applications, including one for chocolates, have been developed and marketed. The dried quality "Isomalt LM" does not contain more than 1% moisture and can be used for plain chocolate masses to be conched up to 80 °C (176 °F) and milk chocolate masses to be conched up to 70 °C (158 °F; Palatinit GmbH, 2004). However, even with this isomalt it is advisable to conche milk chocolate masses containing high milk powder contents below 60–65 °C (140–149 °F) to avoid gritty agglomerates. A maximum conching temperature of 75 °C (167 °F) is however possible when using isomalt milk crumb (Bollinger and Keme, 1988).

The higher hygroscopicity of "Isomalt LM" has to be taken into consideration when it is being stored.

4.7.17 Lactitol

Lactitol is a disaccharide alcohol produced by the hydrogenation of lactose. It can be crystallised out as a mono- or dihydrate as well as in an anhydrous crystalline form. Lactitol is not hygroscopic and has a sweetening power of about