Table 4.9 Relative degree of sweetness of different saccharides and sugar alcohols (adapted from Hyvönen *et al.*, 1977; Carpenter, 1984; Krüger *et al.*, 1996; Frank, 2002).

Sugar	Relative sweetness
Sucrose	1.0
Xylitol	1.0
Fructose	1.2
Maltitol	0.8
Erythritol	0.7
Sorbitol	0.6
Mannitol	0.6
Isomaltulose	0.5
Isomalt	0.45
Lactitol	0.35
Inulin	0.10

There are also synergistic effects. These phenomena cause sugars in mixtures to mutually enhance their sweetening power as well as their other sweetness characteristics. Fructose in milk chocolate has been found to taste only slightly sweeter than sucrose, yet mixtures of fructose and sucrose were very much sweeter. Even though glucose in a 10% aqueous solution shows a markedly lower sweetening power than sucrose, milk chocolates sweetened by anhydrous dextrose tasted almost as sweet as those made with sucrose. The sweetness also increased when part of the sucrose was replaced by anhydrous dextrose. However, glucose leaves a burning taste in the mouth, which rather enhances the impression of sweetness instead of moderating it. Fructose also gives a "pungent" sweetness in milk chocolate, but is felt to be pleasantly mild in, for example, chocolate drinks (Krüger *et al.*, 1987).

At present, theoretical calculations are unable to predict the sweetness of cocoa containing, or other products, in which some or all of the sucrose is replaced by another type of sugar or by a sugar substitute. They can only provide rough guidelines and it is always necessary to carry out sensory evaluation on actual samples of the product. In order to obtain the best results, a range of recipes should be tested.

4.10 Other sensory properties of sugars and bulk sweeteners

Sweeteners differ not only in their degree of sweetness but also in their sweetening character (Krüger and Fairs, 2000). There is a very important difference between monosaccharides and monosaccharide alcohols on the one hand and disaccharides, disaccharide alcohols and polysaccharides on the other.

Table 4.10 Molecular weights (MW) of sugars and bulk sweeteners.

Poly-/disaccharides	MW	Monosaccharides	MW
Polydextrose	~2000	Sorbitol	182
Lactitol	344	Glucose	180
Maltitol	344	Fructose	180
Isomalt	344	Tagatose	180
Sucrose	342	Xylitol	152
Lactose	342	Erythritol	122
Isomaltulose	342		

Monosaccharides, like the sugars glucose, fructose and tagatose and the monosaccharide alcohols sorbitol, mannitol, xylitol and erythritol, have a "burning, scratchy" aftertaste in chocolates and fat fillings. Disaccharides (such as sucrose and lactose) disaccharide alcohols (such as maltitol, isomalt and lactitol) and polysaccharides (such as polydextrose and inulin) have a mild sweetness and no aftertaste in chocolates and fat fillings. This is possibly a result of the higher osmotic pressure caused by the dissolution of the monosaccharides in the saliva compared with that of the disaccharides and polysaccharides. The osmotic pressure depends on the molecular weight of the dissolved substance; the smaller the molecular weight, the bigger is the osmotic pressure at the same concentration. Compared to disaccharides and disaccharide alcohols, monosaccharides and monosaccharide alcohols have significantly smaller molecular weights, which cause higher osmotic pressures. This means, the smaller the molecular weight of a sweetener is, the more it causes a "burning scratchy" aftertaste.

On the other hand chocolates made with polydextrose and/or disaccharide alcohols and sweetened with intense sweeteners, like aspartame, sucralose, stevia and so on often have a somewhat "flat" sweetness. This can be improved by using about 6% fructose or about 5% xylitol or about 4% erythritol.

Table 4.10 gives the molecular weights of common sugars and bulk sweeteners.

As noted earlier, a further sensorial difference between sugar and sugar alcohols is in their heats of dissolution in water. In the case of erythritol and xylitol, for example, this produces a noticeable cooling effect in the mouth. In contrast, polydextrose and inulin release heat of solution (De Soete, 1995). The heat of solution of common bulk sweeteners and sugars in comparison to sucrose is given in Figure 4.2.

In comparison to sucrose, erythritol, xylitol and sorbitol have strong cooling effects. This can be advantageous for the production of refreshing peppermint or fruit fillings for pralines and filled chocolates. In unfilled plain and milk chocolate tablets and bars, a cooling effect is not expected and therefore normally considered undesirable. In this case the cooling effect of