Sugar Reduction in Dairy Food

Subjects: Others
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1. The World Health Organization (WHO) and Public Health England (PHE) recommend cutting down added sugar in processed foods

2. Flavoured milk is one the sources of sugar and calorie intake in all age groups

3. Sugar reduction by partial substitution with natural non-nutritive sweeteners like stevia and monk fruit is one of the most suitable options for food industries

4. Sugar reduction will help manage the chronic diseases like obesity, cardiovascular diseases and diabetes

Keywords: sugar reduction strategies ; flavoured milk ; sweeteners ; stevia ; monk fruit

1. Introduction

The consumption of excessive free or added sugar contributes to total energy intake, and, possibly, to increased body weight [1], the occurrence of obesity [2][3], and associated chronic diseases such as type 2 diabetes [4][5]. Flavoured milk is used to promote milk intake to meet the recommended dietary allowances (RDA) for vitamin D and calcium [4]. Milk appears to be the principal dairy product consumed by children worldwide. It is estimated that between 60–80% of American children's dairy product consumption is comprised of fluid milk [6]. Furthermore, 68% of all milk available to children in schools in the USA is flavoured, of which the majority is chocolate milk [7]. However, the regular consumption of sweetened flavoured milk has been reported to increase energy intake more than 10% as compared with non-consumers [8][9][10]. The increased energy intake is further linked to the occurrence of overweight, obesity [1][2][3], and type 2 diabetes [4][5].

The World Health Organization (WHO) recommends less than 10% of total energy intake from free sugars per day in both adults and children (strong recommendation). A further reduction to below 5% is a conditional recommendation [11]. These guidelines have been considered by Public Health England (PHE), which recommends a 20% sugar reduction in processed foods and beverages by 2020 [12]. A well-tested model of an epidemiological triad (hosts, vectors, and environments) provides a framework to address such public health concerns [13][14]. The vectors rule of this model suggests "small changes × large volumes = significant population benefits". Therefore, even a small reduction can significantly benefit a larger population in the long term.

2. Nutritive Sweetener (NS)

The NSs include sugars such as sucrose, fructose, and lactose, as well high-fructose corn syrup (HFCS), trehalose, and polyols (erythritol, isomaltitol, lactitol, maltitol, sorbitol, mannitol, and xylitol) [15][16]. NSs have various advantages when added to foods and beverages (Table 1), however, they provide calorie contribution. For these reasons, they are not preferred for sugar reduction strategies where calorie reduction is important.

3. Non-Nutritive Sweeteners (NNSs)

Non-nutritive (intensive) sweeteners (NNSs) are food additives with high sweetness potency. They are usually added in low amounts, and therefore their calorie contribution is almost negligible and are preferred for use where calorie reduction is desired (Table 2) [15]. NS and NNS can both be either natural or artificial [17][18][19]. Natural sweeteners are intrinsic to a food substance or commonly occur in nature, e.g., stevia and monk fruit [20], while artificial sweeteners are not found in nature but are synthesized from an existing natural source. The first artificial sweetener approved by the FDA was Saccharin in 1958, while Advantame was the most recent one approved by the FDA in 2014. Similarly, the first natural NNS approved for use by the FDA in 2009 was steviol glycosides with rebaudioside A as the main component.

Furthermore, the physiological effects relating to NNSs and NSs vary greatly. NSs play more of a role in the regulation of hormonal secretion and brain activation to control appetite as compared with NNSs [21]. Considering this evidence, NNSs may serve as a good substitute for sugar reduction strategies.

Table 1. Natural and artificial nutritive sweeteners (NSs), their advantages, disadvantages, sweetness potency, and calorie contribution.

Nutritive Sweeteners (NS)	Type	Advantages	Disadvantages	*Sweetness Potency	Calorie/g	References
Sucrose	Natural	Provides colour, flavour, bulkness and preservative actions against microbes	Contributes calories to diets	1.0	4.0	[22]
Glucose	Natural	Essential energy source for the brain	Contributes calories to diets and affects satiety	0.75×	4.0	[23]
Fructose	Natural	Sweetest carbohydrate in nature	Contributes calories to diets but does not affect satiety like glucose	1.5–1.8×	4.0	[24]
Lactose	Natural	Raw material and prebiotics for probiotics	Less contribution to sweetness	0.11–0.13×	3.9	[25][26]
Trehalose	Artificial	Antioxidant activity, food flavour enhancer; prevents starch aging; odor reduction and extension of the shelf life	Contributes calories	0.5–0.7×	3.6	[27][28][29][30]
Erythritol	Artificial	Highly stable, low calorie contribution, tooth-friendly sweetener providing volume, texture, and microbiological stability	Can cause gastrointestinal symptoms	0.7×	0.2	[31]
Isomalt (Isomaltitol)	Artificial	Heat resistant and tooth-friendly	Laxative effect along with gastrointestinal symptoms (abdominal discomfort, bloating and flatulence if consumed in excess i.e., >50 g)	0.45–0.6×	2.0	[31][32]

Lactitol	Artificial	Low calories suitable for sugar-free foods	Similar to Isomalt	0.35–0.4×	1.9	[31]
Maltitol	Artificial	Heat resistance, strong flavour consistency, and tooth-friendly as it is not fermented by tooth plaque forming microorganisms	Similar to Isomalt	0.5–0.9×	3.0	[31][33]
Sorbitol	Artificial	Bulking agent, humectant, sequestrant and acts as stabilizer	Similar to Isomalt	0.6×	2.6	[31][34]
Mannitol	Artificial	Crystallization in the form of a colourless/white needle/rhombus with extremely low hygroscopicity	Only 18% (w/v) soluble in water at 25 °C	0.5–0.72×	1.6	[35][36][37]
Xylitol	Artificial	Sweetness intensity similar to sucrose	Similar to Isomalt	1.0×	3.0	[32]

* Sweetness potency-the indicated estimate values are times (×) that of sucrose.

Table 2. Natural and artificial non-nutritive sweeteners (NNSs) used for sugar reduction in dairy products.

Non-nutritive Sweetener (NNS)	Structure	ADI (mg/kg Body Weight/day)	Onset	Lingering	Off-taste	Food and Beverages	Amount of Sugar Reduction	Reference
Natural								
Thaumatin		50	Delay	Long	Nil	Probiotic chocolate-flavoured milk	20%	[15][38][39]
Neohesperidine dihydrochalcone		35	Delay	Long	Like licorice	Chocolate, skimmed plain yoghurt	-	[15][40][41]
Steviol glucosides		4	Delay	Moderate	Bitter	Chocolate milk, chocolate dairy desserts	50%	[15][42][43][44][45]

Monk fruit (Mogrosides V)	25	Delay	Long	Nil	Chocolate milk	50%	[42][43][46]
Artificial							
Advantame	5	Delay	Moderate	Nil	Strawberry-flavoured yoghurt	100%	[15][47][48]
Neotame	2	Delay	Strong	Nil	Prebiotic chocolate dairy dessert	100%	[15][45]
Sucralose	5	Slight delay	Moderate	Slight bitter	Strawberry flavoured yoghurt, dairy desserts, lassi	100%	[15][44][48]
Saccharin	5	Rapid	Non-significant	Bitter and metallic	Strawberry flavoured yoghurt, lemon whey beverages	39%-100%	[15][48][49]
Aspartame	40	Slight delay	Moderate	Non-significant	Strawberry flavoured yoghurt, lemon whey beverages, lassi	39–100%	[15][49][50]
Acesulfame K	9	Quick	Low	Bitter and metallic	Strawberry flavoured yoghurt, lassi	100%	[15][50]
Cyclamates	11	Rapid	Non-significant	Bitter and salty	Strawberry flavoured yoghurt	100%	[15]

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