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Functional properties of maltitol

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Abstract. *On the basis of reference data, the functional properties of maltitol, as a sweetener, have been presented and compared with that of traditional sweet ingredient sucrose. The production process of maltitol and the natural raw materials for its preparation have been investigated. The main physical, some chemical and organoleptic properties of maltitol which are directly related to the technology of foods and drinks have been discussed in order to study and compare its rheological behavior to that of sucrose in different products. On the basis of studied data the metabolism process of this alternative sweetener has been presented and its energy value related to its safety use in foods. In virtue of this study the conclusion is made that maltitol-containing confectionery and dairy products offer considerable advantages over traditional sucrose-based products in terms of reduced energy content, reduced cariogenicity and similar rheological behavior to that of sucrose.*

Keywords: sucrose, maltitol, properties, characteristics, sugar- substitute, polyols

Introduction

Sugars are common food ingredients that are found in many forms. As carbohydrates, they are contributor of calories for the body. Thus, they are an important energy source. There are no nutritional differences among sugars. The body uses all types in the same way. During digestion, sugars such as sucrose and other carbohydrates such as starches, break down into monosaccharide (single sugars) and then travel through the blood stream to body cells providing energy and helping to form proteins. Sucrose is commonly used in food industry to prepare sweet taste products, and besides its pleasant sweetness, it performs a host of less-obvious and important functions like imparting delicate structure and high volume in products and retaining moisture, which improves their shelf life.

Common, refined, white granulated sugar is a pure carbohydrate that occurs naturally in every fruit and vegetable. It is a major product of photosynthesis and occurs in the greatest quantities in sugar cane and sugar beets. Chemically sugar is the disaccharide "sucrose" that results from the biochemical bonding of the naturally occurring monosaccharide molecules "fructose" and "glucose". This bond is relatively strong but it is commonly broken by heat, acids, and the enzyme invertase present in human saliva and digestive tracts.

The sugar metabolism in human body is related with rapid entering the bloodstream and raising the blood sugar level. Frequent consumption of sweets may be the reason for the accumulation of excess calories as well as the development of diabetes, hyperglycemia, hypertension, obesity, and dental injuries. These are the reasons for the extremely strong interest in the last decade from producers and consumers to the creation and consumption of low calorie products containing alternative sweeteners. The accelerated pace of growing market of low-calorie diet and sugar-free products, led to the creation of sweeteners with wide range of applications, such as maltitol, sorbitol, xylitol, isomalt, mannitol, etc., and sweeteners with a high degree of sweetness: Aspartame, Sucralose, Acesulfame K etc. (Cock, 1999).

The individual functional properties and physiological characteristics of sweeteners from the group of polyols, including maltitol, are determined by their molecular weight and conformation. Studying them is important for choosing a suitable substitute for sucrose in various low-calorie diet products. Therefore, the development and rationalization of the technologies of producing sweet taste food without sugar is preceded by large research of the functional properties of different sugar substitutes and the comparative assessment of the same with those of sucrose in order to choose the most appropriate of them, which to the highest extent overlap its taste profile, physicochemical and structural properties. Choosing a particular alternative sweetener determines the quality and the main characteristics of the finished product: taste, texture, technology of preparation, storage, etc. (Hadjikinova et al., 2011).

In this regard the aim of this study is to examine the functional properties of maltitol and to make a comparative evaluation with that of the sucrose and other sugar alcohols in order to determine the possibility for its application in a wide range of sugar-free products - milk, baked products and confectionery.

Maltitol is offered on the market in two forms: Maltitol E 965 (i) crystalline form and Maltitol syrup E 965 (ii) (Malcolm et al., 2006). Maltitol E 965 (i) (4-O-ά-glucopyranosyl-D-sorbitol) is a disaccharide alcohol that doesn't exist in nature. It is crystalline odorless powder, with sweet taste. 5 % water solution of Maltitol E 965 (i) is characterized by the possession of a specific rotation of the angle polar light from + 105.5 to + 108.5 degrees. According to the legislation requirements for purity, maltitol content of the commercial product must be not less than 98% and maximum 1 % humidity. Maltitol syrup E 965 (ii) is a clear odorless viscous liquid or white crystalline mass with sweet taste. According to the legislation requirements for purity, maltitol syrup must contain at least 50% maltitol, 8% sorbitol and not more than 31% water.

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Production

With the exception of erythritol, all polyols are produced by catalytic hydrogenation of suitable reducing sugars where reactive aldehyde and ketone groups are replaced by stable alcohol groups. Raw material for production of maltitol is starch obtained from maize, wheat and tapioca. The hydrogenation process takes between one and three hours, in conditions of high temperature (100–150ºC), high pressure (100–150.10^5 Pa) and presence of a suitable catalyst – nikel, molybdenum or palladium (Malcolm et al., 2006).

There are several related routes which can be used to produce maltitol but all share a common first stage in which the starch is liquefied typically by cooking to about 110ºC in the presence of a heat stable β- amylase enzyme. A second cook to 135ºC may then be carried out to ensure all the starch is gelatinised before proceeding to the next stage, where specifically maltose is produced from the starch using a combination of saccharifying enzymes including β-amylase and pullulanase. The latter is added to specifically hydrolyse (1-6) linkages in the starch and thereby open up the starch granules to allow the β-amylase greater access. During this process very high maltose syrup containing 85–95% maltose on dry basis is produced. Then maltose is hydrogenated and melt cristallised to give predominantly powdered maltitol.

Maltitol syrups refer to the group of hydrogenated starch hydrolysates (HSH) and contain at least 50% maltitol and no more than 8% sorbitol on dry basis (Deis, 2012). Maltitol syrup is produced by partial hydrolysis of corn, potato, barley starch or tapioca starch. By varying the conditions (temperature and pressure) and the degree of hydrolysis, different content of hydrogenated di-, oligo- and polysaccharides can be achieved in the final product. The ratio of these components significantly affects the functional properties and physiological characteristics of the obtained maltitol syrup.

Organoleptic and physicochemical characteristics

Maltitol is characterised with sweetness similar to that of sucrose (approved for 1 or 100%). The relative sweetness of maltitol is 0.9 and that of maltitol syrup is 0.6 to 0.9. The intensity of the sweet taste of maltitol is proportional to the concentration of the sweetener. In comparison with other polyols, its relative sweetness is situated between that of xylitol (0.99-1) and that of erythritol (0.6-0.7), as it is shown on Figure 1. The spectrum of taste characteristics of polyol is very close to that of sucrose (Malcolm et al., 2006). Maltitol and maltitol syrups have clean, smooth and harmonious sweet flavour. Advantage over synthetic sweeteners is the absence of unpleasant aftertaste after consumption.

Heat of solution

When the solid forms of some sugars or polyols are placed on the tongue, a distinct cooling effect may be noticed. This is more pronounced with some sweeteners than others. The effect, known as the "heat of solution", is an exchange in energy that can either lower or raise the temperature of a solution when a substance (sugar) is added to water (saliva). The smaller the particle size of the powder, the more quickly it will dissolve and the cooling effect is increased.

Most polyols in crystalline form have a cooling effect, with some being very significantly different from sucrose at 4 kcal/g. Highly cooling polyols such as erythritol (-42.9 kcal/g) and xylitol (-36.6 kcal/g) and sorbitol (-26.5 kcal/g) are perfect for application in products where the cooling sensation is desired (some chewing gums). There are though, formulations like chocolate, where a cooling effect is not desirable and a polyol with higher heat of solution should be selected. Although isomalt, lactitol and maltitol all have low values and do not give any appreciable cooling sensation in the mouth, maltitol gives value closest to sucrose (-5.5 kcal/g). That characteristic confirms maltitol as the product of choice as the optimum sucrose substitute in foods (Malcolm et al., 2006) (Figure 2).

Extent of solubility

The extent of solubility is a fundamental property of a polyol and it is generally defined as the amount of a solute (polyol) that can be dissolved in a solvent (water) at a given temperature before becoming saturated. The extent of solubility of the bulk sweeteners is a desired property and facilitates its dosage for use as substitutes of sucrose. As it is shown on Figure 3 maltitol belongs to the group of well soluble polyols. Also it crystallizes like sucrose, as its crystalline

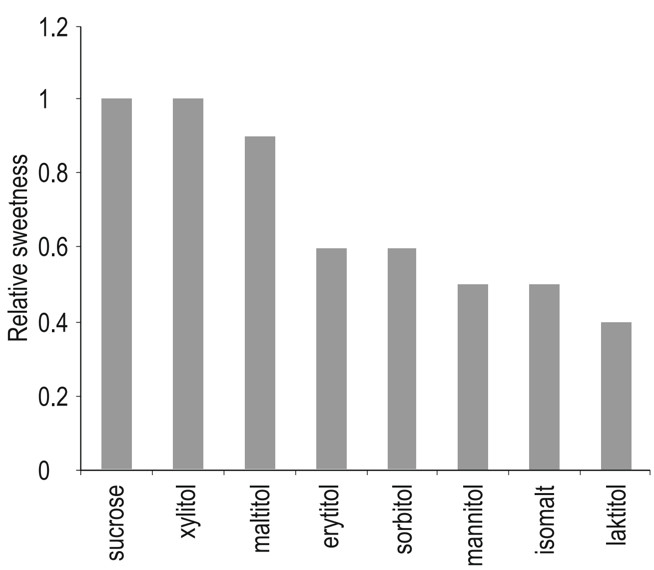

Figure 1. Relative sweetness of polyols and sucrose

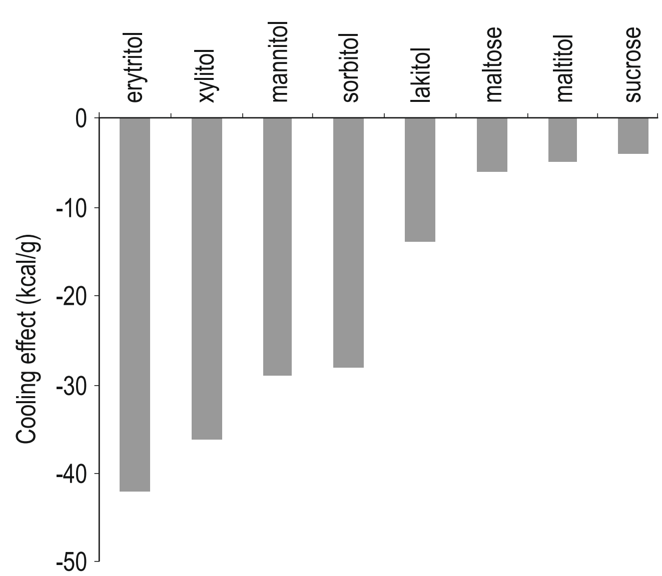

Figure 2. Cooling effect of polyols

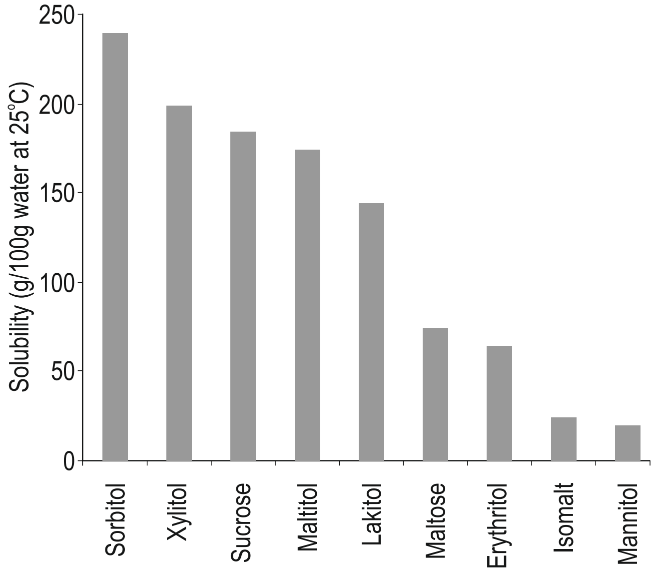

Figure 3. Solubility of polyols and sucrose

form is less hygroscopic. The solubility of maltitol at 20°C is 60 % on dry matter basis and this of the sucrose in water is 67%. At 50°C the solubility of maltitol is 70% and that of water 72% (Dusautois, 2003). These very close characteristics facilitate the application of maltitol as a replacer of sucrose in different low-calorie sweet products.

Maltitol syrups behave more like glucose syrups and for the most part are very soluble (Malcolm et al., 2006). In highly concentrated maltitol syrups (85%) there is a risk of starting a reverse process of crystallization, that is why those with concentrations between 75–80 % are used in practice. Often they are used in combination with other polyols, such as erythritol, lactitol and isomalt in order to prevent their progressing crystallization. Maltitol syrups find application in the manufacturing of a wide range of confectionery, which replace the traditionally used glucose syrups.

Hygroscopicity

The ability of the nutrients to absorb moisture from the environment affects the production process, storage, and expiry date of the final product and also the ingredients that are added to it. Crystalline maltitol is one of the least hygroscopic polyols. It exhibits hygroscopic properties in relative atmospheric humidity of 80%. This makes its storage and transportation easy and there is no need for air conditioning in the manufacturing plant. In the manufacture of sugar-free chewing gums, this property of maltitol is highly valued and important, because the maltitol film-coated dragges retain their crispness and glazed appearance for a significant period of time.

Other properties

Maltitol and maltitol syrups do not participate in Mayard reaction which is a positive quality in order to maintain a pleasant appearance of the product. They are resistant to hydrolysis at pH>3.5.

Maltitol melts at 150°C and it is stable at temperature below 160°C and it does not react with amino acids and so far there is no evidence for adverse interactions with other components of food (Bornet, 1994; Diass, 1999; Dusautois, 2003).

Metabolism

Metabolism of carbohydrates significantly depends on their chemical structure. Polyols are metabolised by two metabolic pathways: absorption in the small intestine and fermentation in the colon. In contrast to glucose, which is absorbed in the small intestine by active transport, polyols are absorbed relatively slowly, so called "passive transport" or diffusion (Duria, 1978). As a result only a limited part of them pass throw the intestinal membrane.

Maltitol is absorbed in amounts of 50–75%, sorbitol in the range of 50–79%, isomalt 50–60%, lactitol 0%, mannitol 50% and xylitol 50%. Initially maltitol is partially hydrolysed to sorbitol and glucose. Unabsorbed quantities in the small intestine pass in the colon where they are fermented by the bacterial micro flora (Beaugerie et al., 1991). As a result of the bacterial fermentation short chain fatty acids are produced. The energy released by absorption of polyols in the small intestine is 17kJ/g (4kcal/g) and the one released by the process of fermentation in the colon is 8.5kJ/g (2kcal/g). The relative energy contribution of the various stages of polyols metabolism determines its metabolic energy.

Studies on volunteers for tolerance, intestinal absorption and energy value of maltitol and other polyols have been conducted (Beaugerie et al.,1991; Storey et al.,1998; Storey et al., 2002). The result shows a good tolerance to sugar alcohols used, including maltitol. The amount of unabsorbed maltitol in the small intestine is about 44 ± 7%, for lactitol and isomalt this indicator is 84±14% and 40±7 %, respectively. The estimated metabolic energy value of maltitol based on these data is 3.1±0.1 kcal/g. In Table 1 the metabolic energy values of polyols accepted in different countries are presented (Bornet, 1994; Langkilde et al., 1994).

The energy value of sucrose traditionally used in confectionery is 4 kcal/g. Compared with data in the table, the energy value of maltitol in different countries is about 30–50% lower than that of sucrose. This determines maltitol as a good substitute for sucrose in the production of low energy foods and appropriate for diabetics confectionery. The energy value of maltitol, like any polyol, is determined not only by the relative energy contribution of different phases of its metabolism but also by the quantity of consumed polyol, the composition of food, physiological status of the individual, the permeability of intestinal tissue etc. (Hadjikinov, 2008).

Maltitol and other polyols (except erythrytol) may manifest secondary reactions revealed in their laxative effect. The laxative effect is explained by the large amount of ingestible molecules that increase the osmotic pressure in the small intestine and stimulate

Table 1. Metabolic energy values of polyols

	Isomalt (kcal/g)	Sorbitol (kcal/g)	Manitol (kcal/g)	Maltitol (kcal/g)	Xylitol (kcal/g)	Erytritol (kcal/g)
Japan	2.0	3.0	2.0	2.0	3.0	0.0
USA	2.0	2.6	1.6	3.0	2.4	0.2
Canada	2.0	2.6	1.6	3.0	3.0	-
Australia	2.9	3.3	2.1	3.8	3.3	0.2
EC	2.4	2.4	2.4	2.4	2.4	-

Table 2. Laxative effect of polyols

Polyols	Maximum dose without laxative effect		
	g/kg body weight		g/day
	men	women	
Sorbitol	0.17	0.24	50
Xylitol	0.30	0.30	50 - 90
Maltitol	0.30	0.30	60 - 90
Isomalt	0.30	-	50 - 70
Erytritol	0.66	0.8	125
Manitol	-	-	20
Lactitol	-	-	20 - 50
Sucrose	-	-	>100
Fructose	-	-	50 - 70
Maltose	-	-	>100

the migration of water from the body (Storey et al., 1998). On Table 2 the laxative effect of each polyol is presented. The body's response to laxative effect depends on the type of polyol, frequency of consumption, quantity and the age of the individual. For example, the acceptable daily intake for children (6-9 years) is 25g maltitol. Intake of such amount of Licasin HBC (maltitol syrup) with candy does not cause laxative effect (Storey et al., 2002).

Glycemic index

The glycemic index (GI) is a measure of the effects of carbohydrates in food on blood sugar levels. It estimates how much each gram of available carbohydrate in food raises a person's blood glucose level following consumption of the food, relative to consumption of glucose. Foods with carbohydrates that break down more slowly, releasing glucose more gradually into the bloodstream, tend to have a low GI. The concept was developed by Dr. David J. Jenkins and colleagues in 1980–1981 at the University of Toronto in their research to find out which foods were best for people with diabetes. A lower glycemic index suggests slower rates of digestion and absorption of the foods' carbohydrates and may also indicate greater extraction from the liver and periphery of the products of carbohydrate digestion.

An appropriate index for quantitative characteristic which allows a comparative assessment of carbohydrates and food (especially those rich in carbohydrates) on the physiological type of absorption in the human body is the value of their GI. The classification of foods and food ingredients according to the value of their glycemic index separates them into the following groups: Substances with high GI (GI>70, white bread, white rice, corn flakes, extruded breakfast cereals, glucose, maltose, maltodextrins), with medium GI (55<GI<70,whole wheat products, basmati rice, sweet potato, sucrose, baked potatoes), low GI (40<GI<55) and very low GI (GI<40) – chick, most fruits, vegetables, legumes, pulses, some whole intact grains, nuts, tagatose, polyols, fructose, kidney beans, ect. According to Livesey (2003), the value of glycemic index of maltitol is 35.27. This value is much lower than the GI of sucrose - 65.43. According to the classification, all polyols, including maltitol, refer to the group of products with very low glycemic index, which makes them suitable as an ingredient in foods and drinks for diabetics (Secchi et al., 1986; Gee et al.,1991; Zumbe and Brinkworth, 1992; Pelletier et al., 1994; Diass, 1999; Zumbe et al., 2001; Wolever et al., 2002).

Dental aspects

Between the various forms of dental diseases, caries dominate by their intensity and fast distribution. Carbohydrates are the third major factor in the etiology of dental caries. Not only the consumption of fermentable carbohydrates, but also the frequency of consumption is important.

Of all carbohydrates, sugar is declared as “main culprit” for the formation of dental caries. This is a complex phenomenon in which enamel is demineralized under the action of lactic, formic, acetic, butyric, and propionic acids. These acids are produced during fermentation of carbohydrates consumed with food by the microorganisms of the dental plaque (Touger-Decker, 2003). It is considered that the critical value of pH at which the process of demineralization of enamel starts is 5.5 to 5.7 (Lingstrom et al., 2000; Toumba et Duggal, 1999). It is considered that foods which do not decrease the pH values lower than 5.5–5.7 are determined as “non cariogenic”. Research on the cariogenic effect of polyols showed that they are safe for health and the hygiene of the oral cavity. Microorganisms found in the dental plaque cannot metabolize this group of additives which do not change critical levels of pH. Recent research shows that maltitol is the only polyol to which even for extended periods of increased consumption (14 days) did not show adaptation to the microorganisms of the dental plaque to metabolize this polyol (Maguire, 2000).

Application in foods

Drinkable yoghurts and flavored milks have increased in popularity in recent years as an alternative to high-sugar beverages and as delivery systems for prebiotics. To reduce the energy content of these products high potency sweeteners and hydrocolloid stabilizers are used. This approach led to a product with distorted texture and unpleasant moth fell of the product. The more practical approach to consider is the addition of maltitol or maltitol syrup to replace the sugar solids as maltitol would contribute significantly to the overall sweetness and texture of the product (Malcolm et al., 2006). Maltitol and maltitol syrups don't participate in Mayard reaction and don't change the good appearance of the product during thermal processing. They are suitable for application in bakery goods, chocolate and hard candy production.

Conclusion

The studies on the functional properties of maltitol give grounds to conclude that it is a sweetener with natural origin, with excellent organoleptic and functional properties. Like other polyols it is produced by catalytic hydrogenation. Its close taste profile to that of sucrose, its good solubility, the low hygroscopisity determine maltitol as an excellent sugar-substitute in sugar-free confectionery and dairy products. Its advantage over synthetic sweeteners is that maltitol does not cause unpleasant aftertaste after consumption. Featuring high food tolerance, virtually non-cariogenic and non-caloric and a sweetener with very low glycemic index, maltitol is very suitable for application in low-calorie foods, diabetic products, pharmaceutical and cosmetic products.

References

Beaugerie L, Flourie B, Pellier P, Achour L, Franchisseur C and Rambaud JC, 1991. Tolerance clinique, absorption intestinale et valeur energetique de quatre polyols pris a jeun. Gastroenterologie clinique et biologique, 15, 929-932.

Bornet F, 1994. Indigestible sugars in food products. American Journal of clinical nutrition, 59, 763-769.

De Cock P, 1999. Erythritol: a novel noncaloric sweetener Ingredient, World Revue of Nutrition and Dietetics, 85, 110-116.

De Cock P and Bechert CL, 2002. Erythritol. Functionality in noncaloric functional beverages. Pure and Applied Chemistry, 74, 1281-1289.

Deis R, 2012. Maltitol syrups and polyglucitols, Alternative sweeteners, fourth edition, Lyn O'Brein Nabours.

Diass FF, 1999. Sorbitol and other sugar alcohols in the food industry. Indian Food Industry 18, 229-237.

Duria M, 1978. Research on influence of some factors on structure and stability of ionique jellies. Thesis for PhD, Higher Institute of Food Industry, Plovdiv (Bg).

Dusautois C, 2003. Maltitol: a complete, functional sugar substitute. Innovations in Food Technology, 14-15.

Gee JM, Cooke P, Gorick S, Wortley GM, Greenwood RH, Zumbe A and Johnson I, 1991. Effects of conventional sucrose-based, fructose-based and isomalt-based chocolates on postprandial metabolism in non insulin-dependent diabetics. European Journal of Clinical Nutrition, 45, 561-566.

Hadjikinova M, Mihov R, Hadjikinov D and Nikovska K, 2011. Comparative rheological characteristic of cocoa dressings with sugar and maltitol. Journal of Food Science, Engineering and Technology (Bg).

Hadjikinov D, 2008, Research and rationalization of process in manufacturing sweet foods without sugar (jelly, chocolate, hard bonbons), Thesis for DSc, University of Food Technologies, Plovdiv (Bg).

Jenkins DS, Wolever TM and Taylor RH, 1981. Glycemic index of foods: a physiological basis for carboxydrate exchange. American Journal of Clinical Nutrition, 34, 362-366.

Krüger D, Grossklaus R, Herold M, Lorenz S and Klingebiel L, 1992. Gastrointestinal transit and digestibility of maltitol, sucrose and Sorbitol in rats: A multicompartmental model and recovery study. Experientia, 48, 733-740.

Langkilde AM, Andersson H, Schweizer T and Wursch P, 1994. Digestion and absorption of sorbitol, maltitol and isomalt from the small – bowel – a study in ileostomy subjects. European Journal of clinical Nutrition 48, 768-775.

Lingström P, Van Ruyven FO, Van Haute S and Kent R, 2000. The pH of dental plaque in its relation to early enamel caries and dental plaque flora in humans, Journal of Dental Research 79, 770-777.

Livesey G, 2003. Health potential of polyols as sugar replacers, with emphasis on low glycaemic properties. Nutritional Research Revue 16, 163-191.

Malcolm W and Kearsley D, 2006. Maltitol and maltitol syrups Sweeteners and sugar alternatives in food technology. Hellen Mithell, 223-248.

Maguire A, Gunn JR and Wright G, 2000. Adaptation of dental plaque to metabolise maltitol compared with other sweeteners. Journal of Dentistry, 28, 51-58.

Pelletier X, Hanesse B, Bornet F and Debry G, 1994. Glycemic and insulinemic responses in healthy-volunteers upon ingestion of maltitol and hydrogenated glucose syrups. Diabetes and metabolism, 20, 291-296.

Secchi A, Pontiroli AE, Cammelli L, Bizzi A, Cini M and Pozza G, 1986. Effects of oral administration of maltitol on plasma glucose. Plasma sorbitol and serum insulin levels in man. Klinische Wochenschrift, 64, 265-269.

Storey D, Lee A and Zumbe A, 2002. The comparative gastrointestinal response of young children to the ingestion of 25 g sweet containing sucrose or isomalt. British Journal of Nutrition, 87, 291-297.

Storey D, Koutsou G, Lee A, Zumbe A, Olivier P, Bot YL and Flourie B, 1998. Tolerance and breath hydrogen excretion following ingestion of maltitol incorporated at two levels into milk chocolate consumed by healthy young adults with and without fasting. Journal of Nutrition, 128, 587 - 592.

Touger-Decker R and van Loveren C, 2003. Sugars and dental caries, American Journal of Clinical Nutrition, 78, 881 - 892.

Toumba KJ and Duggal MS, 1999. Effect on plaque pH of fruits drinks with reduced carbohydrate content. British Dental Journal, 186, 626-629.

Wolever Th, Piekarz A, Hollands M and Younker K, 2002. Sugar Alcohols and Diabetes. Canadian Journal of Diabetes, 26, 356-362.

Zumbe A and Brinkworth R, 1992. Comparative studies of gastrointestinal tolerance and acceptability of milk chocolate containing either sucrose, isomalt or sorbitol in healthy consumers and type II diabetics. Z Ermahrungswiss, 31, 40-48.

Zumbe A, Lee A and Storey D, 2001. Polyols in confectionery: the route to sugar-free reduced sugar and reduced calorie confectionery. British Journal of Nutrition, 85, 31-45.

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Todorov N and Mitev J, 1995. Effect of level of feeding during dry period, and body condition score on reproductive performance in dairy cows,IXth International Conference on Production Diseases in Farm Animals, Sept.11 – 14, Berlin, Germany, p. 302 (Abstr.).

Thesis:

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