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FUNCTION OF FOOD ADDITIVES IN CHOCOLATE PRODUCTION

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professional paper

Summary

Chocolate is a complex product that has a specific texture. This complexity is due to the interactions between the ingredients used in production: cocoa butter, cocoa mass and sugar. Sugar gives bulk to chocolate and any change in the recipe changes the textural properties of the chocolate. Recently, there has been considerable production of low-sugar chocolates using other bulking agents and sweeteners. Some of the most common are isomalt, maltitol, lactitol, polydextrose etc. Emulsifiers that have been used in chocolate production almost from the beginning are also responsible for its texture and rheological properties. They reduce the interaction between the solid particles and increase the lipophilicity of the sugar particles. Lecithin and polyglycerol polyricinoleate are most commonly used, but some other emulsifiers have also been reported in production.

Keywords: food additives, chocolate, emulsifiers, sweeteners

Introduction

Food additives are by Regulation 1333/2008 "any substance not normally consumed as a food in itself and not normally used a characteristic ingredient of a food, whether or not it has nutritive value, the intentional addition of which to a food for a technological purpose in the manufacture, processing, preparation, treatment, packaging, transport or storage of such food results, or may reasonably be expected to result, in it or its by-products becoming directly or indirectly a component of such food".

Two main reasons for using food additives are: making the product safer and making it look and taste better (Saltmarsh, 2013). Since chocolate is a very stable product that has a low content of water (Beckett et al., 2017), food additives that extend the shelf life of food are not necessary in this case.

Emulsifiers are kind of additives that are used in chocolate production for a very long time. They are used for modifying flow properties of chocolate mass for easier manipulation, moulding and acceptable sensory characteristics (Norn, 2015).

Other group of food additives commonly used in chocolate are bulk sweeteners. They are increasingly used in the last few years because of increased popularity of sugar-free products. Chocolate has up to 50% of sucrose in its formulation, so it is an ideal product for replacement of part or whole amount of sugar. Sucrose is responsible for chocolate texture and flavour and with its removal some other bulk sweeteners are used to maintain proper properties of chocolate (Beckett et al., 2017).

Bulk sweeteners

Chocolate production was for a long time unbelievable without sucrose, although lately, sugar-free chocolates have been increasingly studied and produced. In such chocolates different bulk sweeteners are used. They give a sucrose-like texture and taste, most commonly used are polysaccharides and sugar alcohols (polyols).

Sorbitol E420

Sorbitol is monosaccharide alcohol (Fig. 1) which has approximately 50% sweetness of sucrose. It is hygroscopic and gives a cooling effect during consumption and dissolving in the mouth (Beckett et al., 2017). Used in the production of sugar-free chocolate, it gives a suitable texture and mouthfeel (bulking agent) to sugar-free products (Smith and Hong-Shum, 2011). Also, it can be used as a sequestering and emulsifying agent in baked goods, mayonnaise, confectionery products, creams, etc. It has reduced calorie content (2.4 kcal/g) and can be used in products for diabetics. As for other polyols, its permitted addition is at *quantum satis* but content must be labelled if product contains more than 10% (laxative effect) (Saltmarsh, 2013).

When part of sucrose was replaced with sorbitol in milk chocolates, higher quality attributes occurred in this kind of chocolate. Also, using only sorbitol in milk chocolate results in lower viscosity, which needs to be corrected by using starch or guar gum (Rathnavati and Chavan, 2016).

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Mannitol E 421

Mannitol is naturally present monosaccharide alcohol (Fig. 1) which adds mouthfeel and texture of sucrose to sugar-free chocolates. It has the greatest laxative effect in comparison with other sugar alcohols, so adults can take only 10 g of mannitol daily (Beckett et al., 2017). It is used in chewing gums and hard-boiled candies. Since it has low solubility in water it extends the shelf life of products and does not participate in Maillard reactions (Saltmarsh, 2013; Smith and Hong-Shum, 2011).

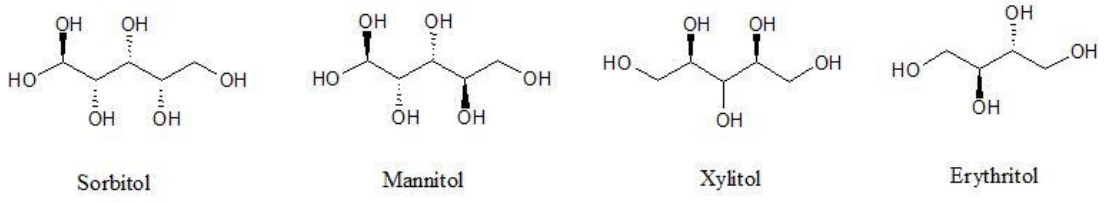

Fig. 1. Monosaccharide alcohols used in chocolate production

Isomalt E953

Isomalt is a polyol derived from a mixture of two disaccharide alcohols (Fig. 2) which has 40% sweetness of sucrose. It is non-hygroscopic, has prebiotic properties and cannot be used in chocolates that are conched at temperatures higher than 45 °C (Beckett et al., 2017). It is used as a bulking agent which gives sweetness and texture in the production of free sugar chocolates. It has an energy value of 2.4 kcal/g and is allowed at a *quantum satis* but if it contains more than 10% it has to be labelled that may have a laxative effect (Smith and Hong-Shum, 2011; Saltmarsh, 2013).

Belščak-Cvitanović et al. (2014) concluded in their study that chocolates with isomalt have larger particle size which directly affects textural properties of chocolate. Also, viscosity of chocolate with isomalt is higher when comparing to maltitol, xylitol and sucrose (Olinger, 1994). Isomalt's increase of chocolate viscosity can be associated with higher solid volume fraction in chocolate. This is because of isomalt's density which is slightly lower than of other sugar alcohols (Aidoo et al., 2013).

Maltitol E965

Maltitol is disaccharide alcohol (Fig. 2), bulk and anhydrous sweetener which can be used at elevated temperatures. It is present in the liquid and crystalline forms. Maltitol syrup has a high content of water so it cannnot be used in chocolates. The crystalline form has 90% sweetness of sucrose. It can be used as a sugar replacer in some other products, such as chewing gum, hard-boiled candies, jams, ice-creams, etc (Beckett et al., 2017; Smith and Hong-Shum, 2011; Saltmarsh, 2013).

Maltitol based chocolates produced and studied by Konar et al. (2018) showed lower sugar melting enthalpies than sucrose containing chocolates. Reason for this could be higher content of moisture in maltitol. This study also examined maltitol's influence on viscosity of chocolate and concluded that maltitol increases viscosity mostly because of different shape of particles and higher moisture content.

Son et al. (2017) examined effect of maltitol on bloom phenomenon in chocolate. This additive showed anti-blooming properties when compared with chocolate made only with sucrose.

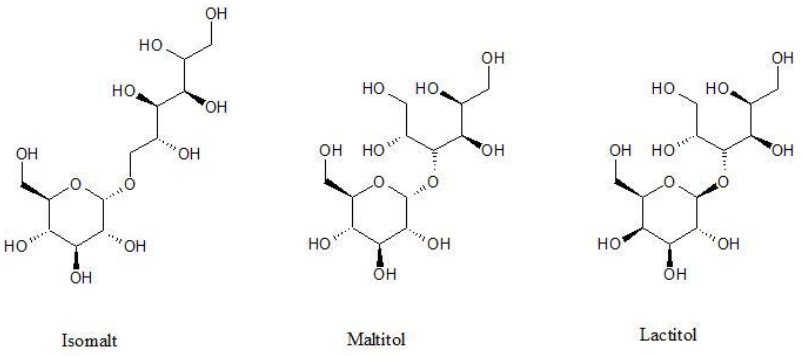

Fig. 2. Disaccharide alcohols used in chocolate production

Lactitol E 966

Lactitol is disaccharide alcohol (Fig. 2) that is hygroscopic and has a sweetness of 40% of sucrose. It is used in the production of sugar-free chocolates and has prebiotic properties. Because of its texture and bulking properties, it can replace sucrose in the chocolate formulation. Its energy value is 2 kcal/g and can be used in diabetic products (Beckett et al., 2017; Smith and Hong-Shum, 2011).
Belščak-Cvitanović et al. (2015) in their study examined the influence of different sweeteners on chocolate properties. The use of lactitol in chocolate formulation resulted in an increase of the hardness but decrease of elasticity of chocolate when compared to conventional chocolate. This is probably caused by the larger particles also caused by lactitol.
Although every change in chocolate affects its properties, using combinations of different sweeteners can produce a product that is not significantly different from the traditional one. Lactitol, maltitol and isomaltulose combinations are most commonly used. This produces a less calorific product with very satisfactory sensory properties (Martínez-Monteagudo et al., 2018; Mentink et al., 1994).

Xylitol E967

Xylitol is natural monosaccharide alcohol (Fig. 1) which can be found in fruits, vegetables and mushrooms. It is obtained by enzymatic conversion of glucose and has a cooling effect during digestion in the mouth (Beckett et al., 2017). It acts as a bulking agent and has the same sweetness as sucrose without any off-flavours. In addition, it can serve as a stabiliser, thickener, emulsifier, humectant, etc. (Smith and Hong-Shum, 2011). As other polyols, it has a laxative effect, cooling effect in the mouth, 2.4 kcal/g energy content and resists fermentation by oral bacteria (Saltmarsh, 2013).
Xylitol has high hydrophilicity because of its structure which has more active and free –OH groups which can react with water. Water in chocolate has big effect on chocolate viscosity. This was proven by Homayouni Rad et al. (2019) where formulation with only xylitol had the highest viscosity values in comparison with formulation with other polyols and theirs combination.

Erythritol E968

Erythritol is monosaccharide alcohol (Fig. 1) which occurs in different fruits and vegetables. This bulk sweetener has a very low caloric value (0.2 kcal/g), can be manipulated under elevated temperatures. Except as a sugar replacer, it can be used as humectant, sequestrant and flavour enhancer. It is possible to have a laxative effect if it's consumed excessively (Beckett et al., 2017; Saltmarsh, 2013).

Polydextrose E 1200

Polydextrose is a bulking sweetener used in sugar-free chocolates. Except for sugar replacement, it can be used also as a fat replacer. It has a caloric value of 1 kcal/g and because of the way of digestion, it is considered dietary fibre (Saltmarsh, 2013). Polydextrose is mostly composed of randomly bonded glucose units and small amounts of sorbitol. During consumption, polydextrose leads to a heating effect in the mouth (Murphy, 2001; Beckett et al., 2017).
In study conducted by Aidoo et al. (2014) polydextrose showed effect on increase of Casson yield stress, but Casson plastic viscosity remained similar to control. Also, particles of chocolate with polydextrose were smaller. This could be the reason for increased Casson yield stress.

Emulsifiers

Emulsifiers have been used in chocolate production for a very long time, mainly because they reduce the tension between the dispersed and continuous phase. They also affect chocolate's sensitivity to moisture and temperature changes, tempering behaviour, and fat migration (Garti and Aserin, 2012).

Lecithin E 322

Lecithin is the most widely used emulsifier in chocolate production, mainly because of its low cost and unique characteristics. Theodore Nicolas Gobley discovered it between 1845 and 1847 by extraction from egg yolk. It got named by the Greek word for egg yolk. Lecithin is of natural origin and can be found in soybeans, egg yolks and whole grains. The human body also contains lecithin, most of it in the vital organs (Garti and Aserin, 2012).
Commercial lecithin used in chocolate production consists of approximately 50-60 wt% phospholipids. The two most common forms used are liquid and powdered (de-oiled) lecithin. In addition to being used as an emulsifier for reducing viscosity in chocolate, it can also serve as an antioxidant (margarine, edible oils and fats), anti-spattering agent (margarine), release agent (baked goods), etc. (Saltmarsh, 2013; Smith and Hong-Shum, 2011).

The phospholipids present in lecithin are active components that contain a two-part molecular structure. One end of the molecule is lipophilic (fatty acid end) and the other is hydrophilic (phosphorus-containing end). Due to their nature, they are located on the border between oil and water (Saltmarsh, 2013). In chocolate, lecithin covers sucrose particles to develop acceptable flow of cocoa butter. This gives a uniform particle distribution in cocoa butter and prevents agglomeration of sugar particles (Schantz and Rhom, 2005). Powdered sucrose used in chocolate production has a larger surface area than granulated sucrose. Absorption of lecithin on the surface of sucrose increases the lipophilicity of sucrose by reducing the acceptor character of the sucrose surface by chains of phospholipids in lecithin. In this way, the interaction between sucrose particles is reduced (Garti and Aserin, 2012).
Ashkezary et al. (2018) and Tisoncik (2010) examined the influence of emulsifiers on chocolate hardness. They concluded that increasing the lecithin content results in softer chocolate texture. Also, Rousset et al. (2002) concluded that the addition of lecithin in the 0.1 to 0.3% content significantly changes the Casson yield value and plastic viscosity, but the addition above 0.5% increases the yield value because the higher lecithin content causes the formation of multiple layers on the surface of sucrose particles (due to reverse micelle formation).
Modified lecithins are also used in chocolate production, and Miyasaki et al. (2015) studied five different ones (acetylated, enzymatically hydrolyzed, hydroxylated, standard and defatted lecithin) and determined their impact on chocolate. Enzymatically hydrolyzed and hydroxylated lecithins had the most pronounced effect on the crystallization of cocoa butter. It was concluded that they had increased the onset temperature of crystallization so it may be said that they act as accelerators of the nucleation of cocoa butter.

Ammonium phosphatides E 442

Ammonium phosphatide is a substitute for synthetic lecithin used as an emulsifier in chocolate production to reduce viscosity. It has no taste and odour that are characteristic of lecithin obtained from soy. It has a similar effect to natural lecithin, settles on the surface of the sugar and reduces the agglomeration of sucrose particles. Unlike natural lecithin, it has a restriction on its use in chocolate. Under Regulation 1129/2011, it is allowed to add 10000 mg/kg of ammonium phosphatide to chocolate (Saltmarsh, 2013).
Unlike lecithin, it gives greater stability to the chocolate against oxidation, and it is possible to add it up to 1%, without affecting the taste and aroma of the product. Also, high doses will not adversely affect the viscosity of the chocolate as is the case with natural lecithin. It can also be added into ice cream coatings and various other confectionery products (Smith and Hong-Shum, 2011; Wood et al., 2004).

Citric acid esters of mono- and diglycerides of fatty acids E 472c

Citrems are used as emulsifiers in sausages and margarine and as a liquid controller in chocolate. They can be present as liquids, pastes and solids (Saltmarsh, 2013). Citrems are sensitive to hydrolysis, they contain water, have a low pH and cannot be stored at elevated temperatures. They are known to be good for reducing plastic viscosity and yield value of chocolates (Norn, 2015).
Beckett et al. (2017) reported that citric acid esters have an effect similar to a combination of PGPR and lecithin on chocolate viscosity. Also, Ashkezary et al. (2018) examined the influence of different emulsifiers on chocolate hardness. They concluded that citrem added in the 1% share had the greatest effect on softening of chocolates when compared with lecithin and PGPR.

Polyglycerol polyricinoleate E 476

Polyglycerol polyricinoleate (PGPR) is complex mixture of polycondensed esters of vegetable polyglycerol polyricinoleic acid. It is edible in oils and it is used as a viscous light brown liquid. PGPR is most commonly used in combination with lecithin because it does not significantly affect plastic viscosity but may therefore reduce yield value by 50%. It is usually added to chocolate in the proportion of 0.1 to 0.5%. Because it significantly influences the yield value, it facilitates the manipulation of chocolate during production and promotes the emergence of bubbles from finished chocolate (Smith and Hong-Sham, 2011; Garti and Aserin, 2012).
PGPR works by increasing the lipophilicity of the sugar surface by reducing the acidic character of the surface of the sugar particles. This reduces the interactions between the particles and increases the fluidity of the fat base. Middendorf et al. (2015) examined the effect of PGPR in cocoa butter suspension and concluded that this emulsifier and cocoa butter actually interact strongly with each other. Schantz and Rohm (2005) reported that best ratio of lecithin to PGPR for minimisation of yield stress is 30:70. Also, hardness of chocolate can be affected by PGPR content. The higher the content of emulsifier, the lower are the values for hardness. This

is because PGPR effects interaction between particles which is mostly responsible for texture of chocolates (Tisoncik, 2010).

Sorbitan tristearate E491

Sorbitan esters are obtained by the reaction of fatty acids with hexitol anhydride. They are non-ionic emulsifiers and are most commonly used for water-in-oil emulsions. They can be used in ice creams, baked goods, but also for modifying the crystal structure in chocolates. The most important role in chocolate is actually the inhibition of fat bloom that occurs during storage (Saltmarsh, 2013).
Cocoa butter, which is a major component in chocolate production, is known to exist in six polymorphic forms. During chocolate storage, the most common transition is from form V to form VI. This is also the reason for the fat bloom which happens during storage. Sorbitan tristearate, by its physical structure, has the effect of slowing this transition. Mostly by producing a rigid structure that will hinder and slow the transition (Garti and Aserin, 2012).

Conclusions

Bulk sweeteners used in the production of sugar-free chocolate have different sweetness intensities, calorific values and influence on the structure of chocolate. There is no universal bulk sweetener when producing chocolate. It is necessary to determine the final effect that is to be accomplish and based on that choose the right sweetener. The emulsifiers used in the production of all kinds of chocolate are already very well known. Most commonly used is soy lecithin, which can be combined with PGPR, but there are other emulsifiers that have benefits and limitations.

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