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Role of Sucrose Ester for Enhancing the Food Quality and Safety: A Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Sucrose esters play a crucial role in contemporary food manufacturing, contributing to the texture, stability, and overall satisfaction of consumers with numerous processed foods. Nevertheless, individuals should remain mindful of potential sensitivities or allergies and inspect ingredient labels carefully when using any food additive. If sucrose esters are manufactured according to excellent manufacturing methods, they are considered safe for eating. Many nations, including the US and the EU, have allowed their use; however, there are certain restrictions on the basis on the types of food products as well as the maximum amount of time they can be used for each application.

Keywords: Food manufacturing; lipophilic balance; sucrose esters; food quality.

1. INTRODUCTION

Sucrose esters, also known as esters of sucrose fatty acid, are collections of surfactants produced through the chemical process of esterifying sucrose with fatty acids or glycerides [1]. One notable characteristic of this group of compounds is the extensive spectrum of hydrophilic-lipophilic balance (HLB) [2]. Sucrose esters are manufactured according to excellent

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manufacturing methods are generally safe for eating [3]. Many nations, including the US and the EU, have allowed their use; however, there are restrictions on the types of food products they can be used in as well as the maximum amount of time they can be used for each application [4]. But some people may have allergies or sensitivity issues, with food additives, so it's important to read ingredient labels if you have any dietary concerns. In 1939, the chemical list Cantor synthesized sucrose fatty acid esters by sucrose esterification with pyridine and either chloroform or carbon tetrachloride as a solvent mixing subsequently during 1950, Foster Snell synthesized both di-substituted and mono-sucrose esters Chen et al. [5], Teng, et al. [6].

1.1 Mode of Action (Mechanism)

Fatty acid chain functions as the molecule's lipophilic end, whilst the polar sucrose moiety acts as its hydrophilic end [7]. Because of this amphipathic characteristic, sucrose esters function as emulsifiers, meaning they may bind water and oil at the same time. Certain emulsifiers can be utilized as water-in-oil emulsifiers or oil-in-water emulsifiers, depending on the HLB value. The resultant sucrose ester becomes less hydrophilic because of fewer free hydroxyl groups and more lipophilic fatty acids.

Sucrose esters have HLB values ranging from 1 to 16. High-HLB (8–18) sucrose esters function as oil-in-water emulsifiers whereas low-HLB (3.5–6.0) sucrose esters function as water-in-oil emulsifiers [8,9,10].

2. STRUCTURE

N-methyl glucamides, alkyl glucosides, sorbitane esters, and sucrose esters are the four main groups. Glycolipids are sugar surfactants that contain several hydrophilic chains. When glucose and fructose are combined, sucrose is produced as a disaccharide known as α-D-glucopyranosyl-(1→2)-β-D-fructofuranoside. Eight hydroxyl groups included in sucrose have the ability to form bonds with fatty acid esters, forming sucrose esters. The three (C6, C1', and C6') of the eight hydroxyl groups on sucrose are primary, and the remaining four (C2, C3, C4, C3', and C4') are secondary. Because of their reduced steric hindrance, three principal hydroxyl groups are more reactive and react with fatty acids first, producing sucrose mono-, di-, or triester. Lauric acid, myristic acid, palmitic acid, stearic acid, and behenic acid are examples of saturated fatty acids that are frequently used in the production of sucrose esters while oleic acid and erusic acid are examples of unsaturated fatty acids.

3. PROPERTIES

Sucrose esters are powders that are not white but off-white. They don't taste like sugar, even though they are made of sucrose. Rather, they have a harsh or bland flavour. The melting point of sucrose esters can range from 40°C to 60°C, depending on the kind of fatty acid and the degree of substitution. Up to 185°C can be applied to these esters without affecting their performance. However, because the sucrose can caramelize, the product's color may alter. Sucrose esters can be added to most foods because they are stable in foods with a pH of 4 to 8. Higher than pH 8 may cause the ester bond to dissolve, releasing the original sucrose and salt of fatty acids. The same thing can happen if the pH is lower than 4.

Following are sucrose esters properties that are valuable in food production.

Emulsification: Sucrose esters help to stabilize emulsions by reducing the surface tension between two immiscible liquids, such as oil and water. This property makes them useful in products like mayonnaise, salad dressings, and margarine.

Stabilization: They can improve the stability of food products by preventing the separation or settling of ingredients

Texture enhancement: Sucrose esters can contribute to the texture and mouthfeel of food products, making them smoother and creamier.

Foam stabilization: In products like whipped toppings and foam desserts, sucrose esters can help stabilize air bubbles, leading to a more stable foam.

Shelf life extension: By improving stability and preventing spoilage, sucrose esters can help extend the shelf life of food products.

4. USE UP

Fruit preservation: Various climacteric fruits, like apples, bananas, cherries, peaches and pears are treated with the fatty acid ester sucrose (E 473) on their surfaces. The coating protects the fruits by trapping breathing gases.

Pharmaceuticals: Pharmaceutical research utilized sucrose esters to act as stabilizers or surfactants on vesicles for drug delivery systems because of their surface properties [11].

Foods: Sucrose esters are widely used as food additives [12]. The usage of sucrose esters, specifically under E 473, is governed by European Parliament and Council Directive No 95/2/EC. This guideline regulates the amount of sucrose esters that can be used in each specific type of food.

5. PREPARATION METHODS

Interesterification, which entails moving fatty acids from one ester to another, is the primary process used to create sucrose esters. Here, the fatty acids that are used to create sucrose esters are already esterified. The emulsion process, the melt process, and the solvent process are the three developed processes.

Solvent process: The steps include mixing sucrose and triglycerides with a base at 90 °C. Initially, DMF was the solvent, but later on, it was changed to DMSO, which is safer and cheaper. This method results in a combination of sucrose monoesters and more substituted esters in a ratio of about 5:1.

Emulsion process: In this method, the idea of a microemulsion is used. Fatty acid, methyl ester, and sugar are transesterified in propylene glycol as the solvent. Both soap or a fatty acid salt and a basic catalyst—such as anhydrous potassium carbonate—are added. The reaction happened between 130 and 135°C. Distillation is used to extract propylene glycol at temperatures higher than 120°C while operating under vacuum. Filtration was used to achieve refined product. 96% of the reaction was yielded. 15% of the sucrose esters were disubstituted, while 85% of them were monosubstituted.

Melting process: The melted sugar was used instead of the solvent. Melted sugar and a type of fat called fatty acid ester (either methyl ester or triglyceride) are mixed with potassium carbonate or potassium soap, which is a basic substance that helps the reaction. This process requires a temperature of 170-190°C. However, using high temperatures can harm the sugar. Later on, a different way of making this mixture was discovered. First, soap made from fatty acids and sugar is dissolved in water. Then, a basic substance and a fatty acid ester are added to the mixture. To get rid of the water and make a liquid mixture, the solution needs to be heated, and the pressure needs to be reduced. The transesterification process happens at temperatures between 110-175°C.

5.1 Application of sucrose ester

Bread:

Dosage: 0.3 - 1.0%
Functional properties: Increased mechanical resistance at the time of kneading. After baking, the volume increases, the crumb softens, uniform cavities are formed, and the shortening oil is saved. The volume is maintained after baking, and the quality is improved.

Noodles:

Dosage: 0.5 - 1.0%
Functional properties: These properties prevent mixed doughs from adhering to machines and noodles. Decreasing the elution of starch into boiling water increases the water content and yield. Prevents retro gradation of boiled noodles during storage.

Sponge cake:

Dosage: 1%
Functional properties: Increases the volume of cake and improves the crumb, working as a softener. The uniformity of the cake is given. Reducing the mixing time of cake batter using the all-in-one method accelerates the cake-making procedure.

Custard cream:

Dosage: 0.5-1.0%
Functional properties: Increased prevention of starch paste dehydration is attributed to the adhesive nature that occurs after gelatinization. Stable emulsions of fatty materials were made.

Biscuits:

Dosge: 0.5-1.0%
Functional properties: Prevents blooming even in high-fat biscuit products. After baking, grain volume increases, and grain length and shortness improve.

Caramel, nougat:

Dosage: 0.5-1.0%
Functional properties: Improves emulsification of molten sugar and oil and prevents. The separation of oil gives a crispness to those of the hard type.

Table 1. Allowing conditions in different food stuff

Food stuff	Maximum Level g/kg OR g/L
Bakery fine wares	10.00
Baking fat emulsions	10.00
Beverage whiteners	20.00
Desserts	5.00
Edible ice	5.00
liquid Canned coffee	1.00
Meat products (Heated)	5.00
Sauces	10.00
Sugar confectionery	5.00

Source: European Parliament and Council Directive. Feb 20, 1995 & wiki/Sucrose_esters#cite_note-17

Chart 1. Case studies

Author	Work	Conclusion
Addo et al. 1995 [13]	Effect of sucrose ester & blends on alveograph characteristics of wheat flour doughs.	The addition of a sucrose ester blend at 0.4% can partially replace shortening in dough formulation.
Kenji et al. 2001 [14]	Effect of hydrophobic chain on phase behavior of sucrose ester	Repulsion among hydrophobic moieties increases as the number of hydrophobic chains / per sucrose unit increases.
Chunli et al. 1999 [15]	Synthesis of dimeric and trimeric sugar-fatty acid esters by enzymatic mehod.	The lipases of C. antarctica and M. miehei aid in the combination of 2-bromomyristic acid with isopropylidene sugars and methyl-a-glucoside. The acylated products can also be chemically combined by these unique enzymes to produce the desired dimers or trimers.
Nair et al. 2012 [16]	Enzymatic synthesis of sugar esters and their function.	The enzyme stuck on chitosan made more lactose ester (84.1%) than the acrylic resin, and the lactose ester did a better job at reducing the surface tension of coconut milk and keeping the emulsion stable, according to the emulsification index.
Nair et al. 2015 [17]	Enzymatic Synthesis and Applications of Sugar Ester in Food Industry	Different types of sugar esters can be made by changing the amount of esterification and the kind of fatty acid or sugar used.
Huan et al. 2009 [18]	synthesis in high-pressure acetone–CO2 system	Using Novozyme 435 catalyst and an enzymatic process, glucose palmitate was produced at 50 C, 65 bar of pressure, and 3% (v/v) acetone content.

Chewing gum:

Dosage: 0.3-0.5%
Functional properties: The chewing gum's plasticity, softness, and chewiness are enhanced, while its tendency to stick to teeth during chewing is prevented.

Chocolate:

Dosage: 0.2-0.5%
Functional properties: Lower viscosity and promotes tempering. Used in conjunction with lecithin. Prevention of blooming.

Milk drink:

Dosage: 0.1 - 0.5%
Functional properties:
Preventing ring formation. A stable emulsion was obtained.

Clinical Approval: Section 16(5) of the Food Safety Standard Act of 2006 discussed sucrose ester, according to the Food Safety and Standards Authority of India (FSSAI). For sucrose ester, they established a GMP value of 10 g/kg, which is advised for bread goods. Japan became the pioneering nation to authorize the utilization of sucrose esters as food additives. In 1959, the Japanese Ministry of Health and Welfare granted its approval for the incorporation of sucrose esters in food products. The use of sucrose esters was also permitted by FAO/WHO in 1969. The European Food Safety Authority (EFSA) identified and catalogued sucrose esters with E number E473. The Food and Drug Administration (FDA) of United States, gave sucrose esters the green light.

6. CONCLUSION

Due to their high functional properties, such as efficient emulsification, the use of sucrose esters (E473) has increased with the increasing growth rates of food additives worldwide. Sucrose esters serve as versatile food additives that offer a variety of functions, such as emulsification, stabilization, texture enhancement, foam stabilization, and shelf life extension.

The food industry commonly uses additives, a product of sucrose and fatty acids, to improve the quality and durability of a wide range of products.

Sucrose esters, when used in compliance with regulations and proper manufacturing practices, are generally deemed safe for consumptionIn essence, sucrose esters play a crucial role in contemporary food manufacturing, contributing to the texture, stability, and overall satisfaction of consumers with numerous processed foods. Nevertheless, individuals should remain mindful of potential sensitivities or allergies and carefully inspect ingredient labels when using any food additive.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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