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Module on

Role of sugar in food

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Introduction

Sugar is the generalized name for sweet, short-chain, soluble carbohydrates many of which are used in food. They are composed of carbon, hydrogen, and oxygen. There are various types of sugar derived from different sources. Simple sugars are called monosaccharides and include glucose (also known as dextrose), fructose, and galactose. The table or granulated sugar most customarily used in food is sucrose a disaccharide ($C_{12}H_{22}O_{11}$). Other disaccharides include maltose and lactose. Sucrose (raw sugar) is found in the tissues of most plants, but is present in sufficient concentrations only in sugar beet (beta vulgaris) and sugarcane (Saccharum spp.) The refining of raw sugar removes unwanted tastes and results in refined or white sugar. The first stage of refining is known as affination and involves immersing the sugar crystals in concentrated syrup that softens and removes the sticky brown coating without dissolving them. The crystals are then separated from the liquor and dissolved in water. The resulting syrup is treated either by a carbonatation or by a phosphatation process. Both involve the precipitation of a fine solid in the syrup and when this is filtered out, many of the impurities are removed at the same time. Removal of color is achieved by using either a granular activated carbon or an ion-exchange resin . The sugar syrup is concentrated by boiling and then cooled and seeded with sugar crystals, causing the sugar to crystallize out. The liquor is spun off in a centrifuge and the white crystals are dried in hot air and ready to be packaged or used. The International Commission for Uniform Methods of Sugar Analysis sets standards for the measurement of the purity of refined sugar, known as ICUMSA numbers; lower numbers indicate a higher level of purity in the refined sugar. Refined sugar is widely used for industrial needs for higher quality. Refined sugar is purer (ICUMSA below 300) than raw sugar (ICUMSA over 1,500).

Types of sugar

Because of its diverse functional characteristics, sugar is used in many types of food preparations. The most common types of sugar available are:

a) Granular sugar: There are many different types of granulated sugar. Some of these are used only by the food industry and professional bakers and are not available in the supermarkets.

The types of granulated sugars differ in crystal size. Each crystal size provides unique functional characteristics that make the sugar appropriate for a specific type of food.

i) Regular sugar: It is the most commonly used sugar in home food preparation. The food industry describes "regular" sugar as extra fine or fine sugar and is the mostly used sugar because its fine crystals are ideal for bulk handling and are not susceptible to caking.

ii) Fruit sugar: Fruit sugar is slightly finer than "regular" sugar and is used in dry mixes such as gelatin desserts, pudding mixes , and drink mixes. Fruit sugar has more uniform crystal size than "regular" sugar. The uniformity of crystal size prevents separation or settling of smaller crystals to the bottom of the box, an important quality in dry mixes and drink mixes.

iii) Bakers' sugar: Bakers sugar is even finer than that of fruit sugar. As its name suggests, it was developed specially for the baking industry. Bakers' sugar is used for sugaring doughnuts and cookies as well as in some commercial cakes and produces fine crumb texture.

iv) Superfine, ultra fine or bar sugar: The crystal size of this sugar is the finest of all the types of granulated sugar. It is ideal for extra-fine textured cakes and meringues (fig15), as well as for sweetening fruits and iced-drinks since it dissolves easily.

v) Confectioners or powdered sugar: This sugar is granulated sugar ground to a smooth powder and then sifted. It contains about 3% corn starch to prevent caking. Confectioner's sugar is available in three grades, on the basis of different degrees of fineness. The confectioner's sugar available in supermarkets is the finest of the three and is used in icings, confections and whipping cream .

vi) Coarse sugar: Coarse sugar is recovered when sugar syrups high in sucrose are allowed to crystallize, thereby making it highly resistant to color change or inversion (natural breakdown to fructose and glucose) at high temperatures. These characteristics are important in making fondants, confections and liquors.

vii) Sanding sugar: Another large crystal sugar, used mainly in the baking and confectionery industries to sprinkle on top of baked goods. The large crystals reflect light and give the product a sparkling appearance.

b) Brown sugars

i) Turbinado sugar: This sugar is raw sugar which has been only partially processed, removing the surface molasses. It is a blond color with a mild brown sugar flavor and is often used in tea .

ii) Brown sugar (Light and dark): Brown sugar retains some of the molasses syrup, which imparts a pleasant flavor. Brown sugar tends to clump because it contains more moisture than white sugar. Dark brown sugar has more color and a stronger molasses flavor than light brown sugar. Lighter types are generally used in baking and making butterscotch, condiments and glazes. Dark brown sugar has a rich flavor that is good for gingerbread, mincemeat, baked beans , and other full flavored foods.

iii) Muscovado or Burbodas sugar: A British specialty brown sugar is very dark brown and has a particularly strong molasses flavor. The crystals are slightly coarser and stickier in texture than "regular" brown sugar.

iv) Free flowing brown sugars : These sugars are specialty products produced by a co-crystallization process. The process yields fine, powder-like brown sugar that is less moist than "regular" brown sugar. Since it is less moist, it does not clump and is free flowing like white sugar.

v) Demerara sugar: Popular in England, Demerara sugar is a light brown sugar with large golden crystals, which are slightly sticky. It is often used in tea, coffee, or on top of hot cereals.

c) Liquid sugars:

i) Liquid sugars: There are several types of liquid sugar. Liquid sucrose (sugar) is essentially liquid white sugar and can be used in products wherever dissolved sugar might be used. Amber liquid sucrose (sugar) is darker in color and can be used where color is not a problem in the product.

ii) Invert sugars: Inversion of sucrose results in invert sugar, an equal mixture of glucose and fructose. Invert sugar is sweeter than white sugar. It is used mainly in food products to retard crystallization of sugar and retain moisture.

Role of sugar in bakery products

Cakes, cookies , quick breads and yeast breads require sugar for flavor, pleasing color, tender texture, evenness of grain, moisture retention, improved shelf life, and yeast fermentation.

a) Role of sugar in gluten development: During the mixing process, sugar acts as a tenderizing agent by absorbing water and slowing gluten development. During the mixing of batters and dough's flour proteins are hydrated (surrounded with water) forming gluten strands. The gluten forms thousands of small, balloon-like pockets that trap the gases produced during leavening. These gluten strands are highly elastic and allow the batter to stretch under expansion of gases. However, if too much gluten develops, the dough or batter becomes rigid and tough. Sugar competes with these gluten-forming proteins for water in the batter and prevents full hydration of the proteins during mixing. As a consequence, less gluten is allowed to "develop," preventing the elastic dough or batter from becoming rigid. With the correct proportion of sugar in the recipe, the gluten maintains optimum elasticity, which allows for gases to be held within the dough matrix. These gases, from leavening agents and mixing, expand and allow the batter or dough to rise. By preventing the gluten development, sugar helps to give the final baked product tender crumb texture and good volume.

b) Role of sugar in leavening: Sugar increases the effectiveness of yeast by providing an immediate, more utilizable source of nourishment for its growth. Under recipe conditions of moisture and warmth, sugar is broken down by the yeast cells , and carbon dioxide gas is released at a faster rate than if only the carbohydrates of flour were present. The leavening process is hastened and the dough rises at a faster and more consistent rate.

c) Role of sugar in creaming: Sugar crystals become interspersed among the shortening molecules when shortening and sugar are creamed together. In cakes and cookies sugar helps promote lightness by incorporating air into the shortening. When sugar is mixed with shortening, the air becomes incorporated as very small air cells. During baking, these air cells expand when filled with carbon dioxide and other gases from the leavening agent.

d) Role of sugar in egg foams: Sugar serves as a whipping aid to stabilize beaten egg foams. In foam type cakes, sugar interacts with egg proteins to stabilize the whipped foam structure. In doing so, sugar makes the egg foam more elastic so that air cells can expand and take up gases from the leavening agent.

e) Caramelization: Sugar caramelizes when heated above its melting point, adding flavor and leading to surface browning. At about 175°C (or 347°F), melted dry sugar takes on an amber color and develops an appealing flavor and aroma. This amorphous substance resulting from the breakdown of sugar is known as caramel. In baking a batter or dough containing sugar, caramelization takes place under the influence of oven heat, and is one of two ways in which surface browning occurs. The golden-brown, flavorful and slightly crisp surface of breads, cakes, and cookies not only tastes good but also helps to retain moisture in the baked product.

f) Maillard reactions: At oven temperatures, sugar chemically reacts with proteins in the baking product, contributing to the food's browned surface. These maillard reactions are the second way in which bread crusts, cakes, and cookies get their familiar brown surfaces. During baking of breads, cakes, and cookies, maillard reactions occur among sugar and the amino acids, peptides or proteins from other ingredients in the baked products, causing browning. These reactions also result in the aroma associated with the baked good. The higher the sugar content of the baked good, the darker golden brown the surface appears.

- Role of sugars in fruit based products

In jellies, marmalades, jams, and preserves, sugar helps to capture and preserve flavor, aroma, color and qualities of the various fruits.

i) Gelling: Sugar is essential in the gelling process of jams, preserves and jellies to obtain the desired consistency and firmness. This gel-forming process is called gelation, where the fruit juices are enmeshed in a network of fibers. Pectin, a natural component of fruits, has the ability to form this gel only in the presence of sugar and acid. Sugar is essential because it attracts and holds water during the gelling process. The amount of gel-forming pectin in a fruit varies with the ripeness (less ripe fruit has more pectin) and the variety (apples, cranberries and grapes are considerably richer in pectin than cherries and strawberries). In the case of a fruit too low in pectin, some commercial pectin may be added to produce the gelling, especially in jellies.

b) Color retention: Sugar helps to retain the color of the fruit through its capacity to attract and hold water. Sugar absorbs water more readily than other components, such as fruit, in preserves and jellies . Thus, sugar prevents the fruit from absorbing water that would cause its color to fade through dilution.

c) Sugar in canning (fig46): Sugar is used in the canning and freezing of fruits to improve flavor and texture, and to preserve natural color and shape. Fruit to be canned is placed in syrup of greater sugar concentration than that of the fruit itself. The dissolved sugar in the syrup diffuses into the fruit (osmosis) and improves its flavor. In addition, sugar, upon entering the cells, also helps to minimize oxidation, and prevents the fruit's firm texture from becoming mushy. As the fruit cooks in the syrup, the cell wall becomes more permeable, the fruit texture becomes tenderer, and the retention of the sugar renders the fruit plump and attractive.

- Sugar in non-sweet foods

1. Sugar enhances or brings out the flavors that are already in the barbecue sauce. It enhances the tomato, vinegar or lime flavors that may be present in the sauces. Sugar has an optimum taste between 100°F-125°F and tastes better when heated. Because sugar can withstand high temperatures, it is a good choice for barbecue sauces. Additionally, sugar provides superior taste, consistency and performance over other sweeteners in barbecue sauce applications.
2. Sugar enhances flavor, browning, and crusting of meat, fish , and poultry, and contributes to osmosis during the smoking step in the barbecue process. A dry rub or dry marinade is a mixture of sugar (often white and brown), salt, and crushed herbs or spices that is applied to a protein's surface prior to cooking. Sugar contributes to osmosis, creation of the crust as well as caramelization and flavor enhancement.
3. Sugar balances acid flavor and helps maintain the texture of pickled vegetables. Besides balancing the flavor of the vinegar, sugar helps in strengthen vegetable cell structures and makes vegetable fibers firmer. Either brown or white sugar can be used. Brown sugar produces darker brine.

- Role of sugar in food preservation

There are several ways in which sugar inhibit microbial growth. The most notable is simple osmosis, or dehydration. Sugar, whether in solid or aqueous form has an effect of drawing available water from the food to the outside and inserting sugar molecules into the food interior. The result is a reduction of the water activity (a_w), a measure of unbound, free water molecules in the food that is necessary for microbial survival and growth. The water activity a_w of most fresh foods is 0.99, whereas the a_w necessary to inhibit growth of most bacteria is roughly 0.91. Yeasts and molds, on the other hand, usually require even lower a_w, preventing their growth. The antimicrobial mechanism of sugar includes interference with a microbe's enzyme activity and weakening the molecular structure of its DNA. Sugar may also provide an indirect form of preservation by accelerating the accumulation of antimicrobial compounds e.g, the conversion of sugar to ethanol in wine by fermentative yeasts or the conversion of sugar to organic acids in sauerkraut by lactic acid bacteria.