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COIMBATORE-641 035, TAMIL NADU

19FTB202- BIOCHEMISTRY FOR FOOD TECHNOLOGY

UNIT 1- CARBOHYDRATES

TOPIC 4 OLIGOSACCHRIDES

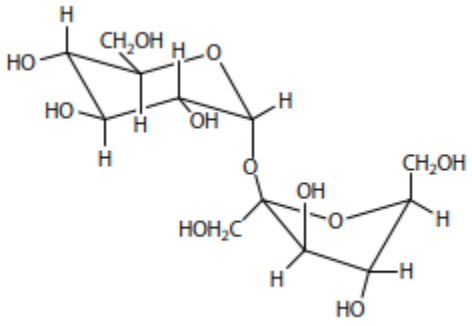
OLIGOSACCHARIDES

Oligosaccharides are composed of up to 20 monosaccharide units. Oligosaccharides often have colligative properties; which means that they can cause freezing point depression and boiling point elevation in food systems.Digestible oligosaccharides represent a quick source of energy in human beings. Nondigestible oligosaccharides often have prebiotic properties. Prebiotics are food ingredients that selectively enhance a population of desirable bacteria (Bifi dobacteria and Lactobacillus) in the large intestine . Oligosaccharides can also be used to help stabilize probiotics in food systems. Probiotic foods contain a culture of microorganisms that improve the intestinal microbial balance of the consumer.

SUCROSE

Occurrence in Plants

Sucrose, a disaccharide, is composed of α-d-glucose and β-d-fructose units that are linked (1→2) through their reducing ends . Thus, sucrose is a nonreducing sugar. Sucrose is made in the cytoplasm of cells in photosynthetically active tissue and is translocated via phloem to metaboli-cally active sites, where it is usually cleaved into glucose and fructose and used as intermediates in various metabolic pathways. In plants such as sugar beet (Beta vulgaris) and sugarcane (Saccharum spp.), sucrose is a storage carbohydrate. In sugarcane, sucrose accumulates in the vacuoles of cells located in the internodal region of the stem, while in sugar beet, sucrose accumulates in the vacu-oles of cells located in root tissue .



Sucrose

Commercial Production

Sucrose is commercially extracted from sugar beet and sugarcane. Extraction from sugar beet begins with the washing and slicing of the roots into strips. The strips are placed in a large tank where raw sugar is extracted in hot water. Sucrose extraction from sugarcane begins by breaking and grinding the stems. The juice is squeezed out by passing the ground stems through a series of rolls. For both sugar beet and sugarcane, the raw sugar juice is clarified using a mixture of lime and carbon dioxide. The carbon dioxide reacts with the lime to produce calcium carbonate. Nonsugar particles attach to the calcium carbonate and precipitate. The juice is filtered and boiled under vacuum, which removes water and leaves a thick syrup. This material is filtered and centrifuged, and the sugar is washed with hot water and dried.

Food Uses

Sucrose affects colligative properties of water in food systems by depressing freezing point and elevating boiling point and can delay starch gelatinization . Sucrose can interact with ingredi-ents to enhance the retention of aroma and flavor of foods . Its antioxidant properties have been used to prevent the deterioration of flavor in canned fruit. Its humectant properties have been used to prevent moisture loss from baked products. Sucrose can provide a yellow-brown color to food products, through thermal degradation, alkaline degradation, and Maillard products.

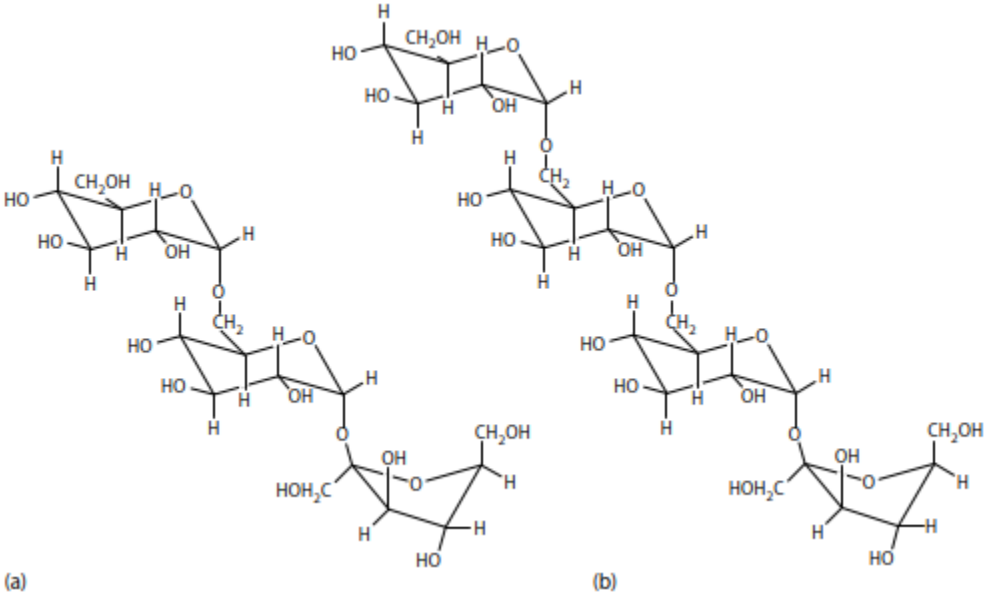
Healthful Properties

Sucrose is rapidly degraded into glucose and fructose, which are readily absorbed into the blood-stream in the small intestine. Sucrose provides a quick source of energy for the human body. However, overconsumption of sucrose can cause adverse health problems. It can contribute to obesity, dental caries, and can be problematic to people suffering from defects in glucose metabolism, e.g., hypoglycemia.

RAFFINOSE FAMILY OLIGOSACCHARIDES

Occurrence in Plants

Raffinose family oligosaccharides (RFO) are composed of sucrose and a varying number of α-d-galactosyl units. Raffinose and stachyose are two common members of RFO, found in plants. Raffinose is composed of glucose, fructose, and galactose . Stachyose is similar to raffinose but contains an additional α-d-galactosyl unit . These α-d-galactosides are formed by α(1–6) galactosides linked to the C-6 of the glucose unit of sucrose.Stachyose is the principal transport carbohydrate in the phloem of some herbaceous and woody plants . Raffinose and stachyose are found in leguminous seeds such as soybean (Glycine max) and lupine (Lupinus spp.) where they prevent desiccation of seeds after maturity [21] and serve as carbon reserves for use during germination .



(a) Raffinose and (b) stachyose

Commercial Production

Sugar beet molasses contains about 18% raffinose. Commercially, raffinose is removed from beet molasses through chromatographic separation.

Food Uses

Raffinose and stachyose occur naturally in food containing legumes. They can be degraded during food processing since they are heat labile. Raffinose and stachyose, along with other RFOs, have potential use in aiding the survival of probiotics in food systems . However, because of their tendency to produce flatulence in human beings, these sugars are generally not selectively added to food products.

Health Properties

Human beings lack α-galactosidase enzymes needed to digest these sugars. Raffinose and stachyose contain α-(1–6) linked galactose, which is cleaved only by bacterial α-galactosidases in the lower part of the gut. Galactose released from raffinose and stachyose can be a source of absorbed galac-tose.

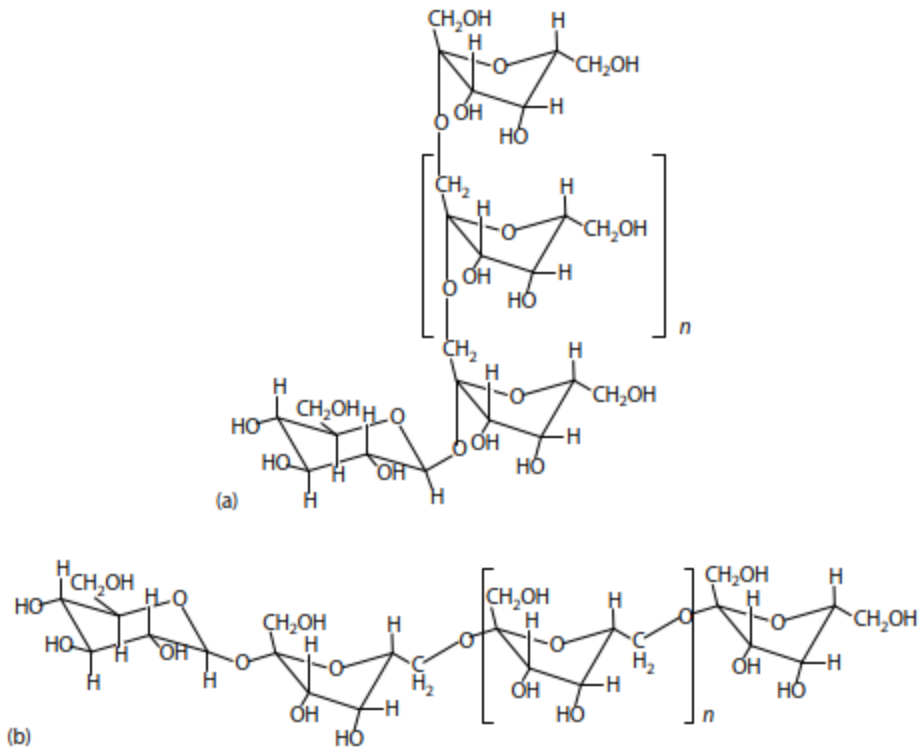
Raffinose and stachyose can promote the growth of Bifidobacteria population in the large intestine, and consequently have potential as prebiotic ingredients in functional foods .

FRUCTANS

Fructans can occur as oligosaccharides and polysaccharides. This means that their degree of polymerization can vary from below 20 sugar units to well above 20 sugar units. As a food ingredient, fructans often have a degree of polymerization of 25 or less. Thus, they are discussed as oligosaccharides.

Occurrence in Plants

There are five classes of fructans: inulin, levan, mixed levan, inulin neoseries, and levanneoseries . Inulin is a linear polysaccharide composed of (2-1)-β-d-fructosyl units . Levan is a linear polysaccharide composed of (2-6)-β-d-fructosyl units .Mixed levan is a branched polysaccharide composed of (2-1) and (2-6)-β-d-fructosyl units. Inulin neoseries is a lin-ear polysaccharide composed of two inulin polymers that are connected together by a sucrose mol-ecule. Levan neoseries is a linear polysaccharide composed of two levan polymers linked together by the glucose unit of the sucrose molecule. The type of fructan produced varies with plant species. For example, plants such as chicory (Cichorium intybus) and Jerusalem artichoke (Helianthus tuberosus) in the Asteraceae family produce inulin. Plants in the Liliaceae family such as garlic (Allium sativum) produce inulin neoseries. Plants in the Poaceae family such as wheat (Triticum spp.), barley (Hordeum vulgare), and oats (Avena sativa) produce mixed levan or levan neoseries.Plants that produce fructans grow in temperate climates where seasonal drought and/or frost are common. There is some evidence that fructans are involved in providing tolerance to drought and/or low temperature. In certain plants, such as chicory and Jerusalem artichoke, fructans serve as a carbohydrate reserve. Fructans are synthesized in the vacuoles of plants. Sucrose from chloroplast is translocated to a storage vacuole in the same cell or translocated to the primary storage organ (tuber, root). In the vacuole, the sucrose is converted into fructan by two or more different fructosyltrans-ferases. The first enzyme initiates fructan synthesis by catalyzing the transfer of a fructosyl residue from sucrose to another sucrose molecule. The second enzyme transfers fructosyl residues from a fructan molecule to another fructan molecule or to a sucrose .



(a) Inulin and (b) levan

Commercial Production

Roots of chicory and Jerusalem artichoke can contain more than 70% inulin on a dry basis . Thus, much work has been conducted on commercializing fructan production using chicory and Jerusalem artichoke. Commercially, inulin is extracted by partial enzymatic hydrolysis using an endo-inulinase, followed by spray drying . Fructo-oligosaccharides (FOS) can be synthesized from sucrose using fructosyltransferase . Extracted inulin typically has a degree of polymeriza-tion of 12–25, while FOS have a degree of polymerization of 3–6 . Ground Jerusalem artichoke (>70% inulin) has been used as an ingredient without further processing .

Food Uses

Fructans, inulin, and FOS have food ingredient status in most countries and are recognized as GRAS ingredients in the United States. In general, fructans have a bland neutral taste with no off-flavor or aftertaste . Fructans are used in a wide range of food products such as bakery products, breakfast cereals, drinks, and dairy products. Fructans are heat labile and will break down under low pH .Fructans have humectant properties that reduce water activity and improve microbiological stability. When mixed with water, inulin can form a particle gel network, resulting in a white creamy structure with a short spreadable texture . Emulsion of long-chain fructan in water has organoleptic properties similar to fat and has been used as a fat replacement in food systems. Inulin works in synergy with most gelling agents.FOS are very water soluble and have some sweetness (30%–35% of sucrose) . FOS are used in

beverages where they improve mouthfeel, enhance fruit flavor, and sustain flavor with less after-taste when added to artificial sweeteners, aspartame or acesulfame K.

Healthful Properties

Fructans are a recognized form of dietary fiber. Digestive enzymes in the human small intestine are specific for α-glycosidic linkages. Thus the β-configuration of the anomeric carbon makes fructans resistant to hydrolysis in the human small intestine . Kolida et al. summarized several studies that document the prebiotic effect of fructans. Fructans are an efficient carbon source of beneficial Bifi dobacteria in the colon, which enhances the growth of healthy gut microflora while suppressing the growth of pathogenic bacteria . Fructans promote mineral absorption, particularly calcium , enhance immune functions and antitumor activity, and may modulate lipid and carbohydrate metabolism for good cardiovascular and diabetic health .