NebGuide

University of Nebraska–Lincoln Extension, Institute of Agriculture and Natural Resources

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G1458
(Revised May 2010)

Sweeteners

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Consumers have a choice of sweeteners, and this NebGuide helps them make the right choice.

Sweeteners of one kind or another have been found in human diets since prehistoric times and are types of carbohydrates. The role they play in the diet is constantly debated.

Consumers satisfy their "sweet tooth" with a variety of sweeteners and use them in foods for several reasons other than sweetness. For example, sugar is used as a preservative in jams and jellies, it provides body and texture in ice cream and baked goods, and it aids in fermentation in breads and pickles.

Sweeteners can be nutritive or non-nutritive. *Nutritive* sweeteners are those that provide calories or energy — about four calories per gram or about 17 calories per tablespoon — even though they lack other nutrients essential for growth and health maintenance. Nutritive sweeteners include sucrose, high fructose corn syrup, corn syrup, honey, fructose, molasses, and sugar alcohols such as sorbitol and xytilo. *Non-nutritive* sweeteners do not provide calories and are sometimes referred to as artificial sweeteners, and non-nutritive in this publication.

In fact, sweeteners may have a variety of terms — sugar-free, sugar alcohols, sucrose, corn sweeteners, etc. — but each sweetener has specific applications and limitations.

The significant difference between sugar sources is not between "natural" and "refined," but between concentrated sugars such as honey, table sugar, concentrated fruit juices, and corn sweeteners, and diluted sweeteners, naturally occurring sugars in foods such as oranges, corn, milk, and potatoes.

Fructose, for example, is the major sugar in fruit and furnishes the same calories per gram as refined table sugar and honey. The difference is that sugar in fruit is diluted in a large quantity of water that also contains vitamins, minerals, and fiber.

Carbohydrates

In humans, the carbohydrate's primary role is to supply energy; one gram of carbohydrate contains four calories (energy). In fact, the body prefers this source of energy over all other available sources of energy nutrients.

Carbohydrates are known as the "energy-sparing nutrient" because the energy available from them spares protein from being used for energy so that protein may build and repair body tissue. When a diet lacks carbohydrates, protein is used for energy.

Sweeteners can be used not only in beverages like coffee, but in baking and as an ingredient in dry foods.

Carbohydrates are found in almost all plant foods and one animal source — milk. The simpler forms of carbohydrates are called sugars, and the more complex forms are either starches or dietary fibers. *Table I* illustrates the classification of common carbohydrates:

Table I. Classification of most common carbohydrates.

Monosaccharides (Single Sugars)	*Disaccharides (Double Sugars)*	*Polysaccharides (Complex Sugars)*
Glucose	Sucrose	Starch
Fructose	Lactose	Glycogen
Galactose	Maltose	Cellulose (fiber)

Sugars

Sugar plays a role in dental cavities, which are caused by the acid byproduct of bacterial growth in the mouth. Bacteria thrive on carbohydrates and produce acid for 20 to 30 minutes after carbohydrates are consumed. Therefore, sugars are implicated as the cause of cavities. Any carbohydrate-containing food — including bread, bananas, milk, and concentrated sugar — can support bacterial growth.

Brushing after eating carbohydrates and once-a-day flossing may effectively prevent cavity formation, regardless of the

carbohydrate content of the diet. Some people may never get cavities because they have inherited resistance to them.

All natural sugars are composed of simple carbohydrates. Carbohydrates are classified in three categories: monosaccharides (one unit of sugar), dissaccharides (two units of sugar), and polysaccharides (many units of sugar).

Monosaccharides

Fructose is 1½ times as sweet as sucrose and is the sweetest of all natural sugars. It is found in fruits and honey and is known as fruit sugar or levulose.

Glucose is in nearly all plant foods. Known as the "blood sugar," because it is the main sugar circulating in blood, glucose is the primary form into which the body converts other sugars and carbohydrates. Another name for glucose is dextrose. Glucose is unusual in that it is rapidly absorbed in the bloodstream, and to some degree, through the lining of the mouth.

Galactose is rarely found free in nature. It is usually found attached to glucose in lactose.

Disaccharides

Sucrose, the most abundant sugar in plants, is a disaccharide composed of two simple sugars. When sucrose is digested, it separates the chemically attached simple sugars — glucose and fructose — for the body to absorb and use for energy.

Sucrose is the most common sugar for household and industrial use, and is produced by concentrating the sugar from sugarcane or sugar beet juice.

Traditionally, the word "sugar" has implied sucrose, but this can cause confusion because there are so many other sugars currently on the market. Sucrose is purified and granulated to various stages to provide raw, white, brown, and powdered sugars. During processing, a dark-colored liquid — molasses — is produced.

Lactose is the sugar found in milk, and is sometimes referred to as milk sugar. Lactose is primarily used in products to provide bulk. It is seldom used as a sweetener because it is the least sweet of the sugars.

Lactose has two monosaccharide units, glucose and galactose, which are normally broken apart by the enzyme lactase. Some individuals lose the ability to digest lactose and become lactose-intolerant, meaning they do not have or have reduced levels of the enzyme, lactase.

Cheese, although it's a milk product, has little lactose because the lactose is changed to lactic acid during fermentation.

Maltose, sometimes referred to as malt sugar, is produced during bread- and beer-making. During digestion, maltose is split into two glucose units so they can be absorbed.

Other Sugars

Honey is a natural syrup made from plants by honey bees. The same sugars in honey are found in table sugar — fructose and glucose. Honey is more concentrated than crystalline table sugar so it contains more calories per equal measure than table sugar.

Honey is often said to be more nutritious than sugar. That is misleading. Although it does provide trace minerals and B vitamins, the amounts are so minute that their contribution to an overall diet is insignificant.

Maple sugar is produced by boiling off liquid from the syrup derived from the spring flow of sap of mature sugar maples. Maple sugar is mainly sucrose.

Corn syrup is a glucose sweetener developed in the 1920s by treating cornstarch with acid, heat, and/or enzymes. Corn syrup is not as sweet as sucrose, but is often used with or in place of sucrose to provide body and texture in food.

High-fructose corn syrup is made from corn syrup by converting glucose into fructose. This unique enzymatic process, developed in 1970, provides a much sweeter product, allowing a reduction in quantity used. The soft-drink industry uses high-fructose corn syrup as its main nutritive sweetener; it may be listed as corn sweetener or high fructose corn syrup on a label.

Agave nectar is a sweetener produced from several species of the agave plant, native to Mexico. Agave nectar is composed primarily of fructose and honey and tastes similar to honey. When substituting for honey, use an equal amount of agave. When substituting for granulated sugar, use ⅔ cup of agave for each cup of sugar and reduce liquids by ¼ cup.

Sugar alcohols are sweeteners commercially produced from glucose, or derived from fruits and vegetables. The most common sugar alcohols are sorbitol, mannitol, maltitol, and xylitol. Prunes have the largest amount of naturally occurring sorbitol of any fruit normally eaten in the United States. Apples and pears also are high in sorbitol.

Sugar alcohols are found in diabetic candies, chewing gums, and as coating on gums. Products containing sugar alcohols may carry the label "sugarless," "sugar free," or "no sugar," but they are still carbohydrates and supply calories.

Sugar alcohols do not promote tooth decay. They are absorbed more slowly than sugars, which may be the reason they can have a laxative effect.

Non-nutritive Sweeteners

Non-nutritive sweeteners do not provide any calories when consumed and must pass the approval of the Food and Drug Administration before they can be marketed in the United States. The six non-nutritive sweeteners currently approved by the FDA are saccharin, aspartame, acesulfame-K, sucralose, neotame, and rebaudioside A.

Saccharin

Saccharin was discovered in 1879 and has been marketed for over 80 years. Due to the length of its safe use, saccharin was given GRAS (Generally Regarded As Safe) status. Saccharin has not been shown to cause cancer in human beings. Saccharin is about 300 times sweeter than sucrose and is stable within a wide range of temperatures.

In 1977, the FDA proposed removing saccharin from public use because of a Canadian study of saccharin and bladder cancer in rats. Public opposition led Congress to pass a moratorium on FDA's action to take saccharin off the market. This moratorium is still in effect.

In 2000, saccharin was removed from the list of substances reasonably anticipated to be a human carcinogen. Saccharin no longer has to carry a warning label.

Aspartame

Aspartame is a non-nutritive sweetener discovered in 1965. It is 180-200 times sweeter than sucrose. In 1981, the FDA approved aspartame as a tabletop sweetener and as an ingredient in dry foods, such as dry beverage mixes and cold cereals. In 1983, approval was extended to carbonated beverages.

Aspartame is mostly marketed in the U.S. under the trade names of NutraSweet® and Equal®, but the patent for aspartame has now expired and it may be sold under other brand names. Aspartame provides the same energy as any protein, four calories per gram, because aspartame is the methyl ester of two amino acids (proteins) — aspartic acid and phenylalanine. It doesn't contribute a significant amount of calories because of the small amount needed to sweeten products.

Due to a possible excess of phenylalanine for phenylketonuric (PKU) children, aspartame must carry a warning label stating: "Phenylketonuric: contains phenylalanine." Phenylketonuria is a genetic disease in which the body cannot produce the enzyme necessary for the body to use phenylalanine.

The FDA set the Acceptable Daily Intake (ADI) of aspartame at 50 milligrams per kilogram of body weight. In terms of aspartame-sweetened soft drink usage, this equals seven 12-ounce cans for a 50-pound child or about 20 cans for a 150-pound adult. Adequate data isn't available to establish aspartame's safety for children younger than 2, but few reasons exist, if any, to use a sugar substitute for children younger than 2, since children need energy to grow.

The use of aspartame is limited at high or prolonged temperatures because it breaks down and loses its sweetness. When using aspartame in cooking, add it near the end of the cooking cycle to help prevent the product from breaking down. If a food containing aspartame is inadvertently heated, it will be safe but will not provide the desired sweetness.

Some individuals have questioned the safety of aspartame, but it is one of the most tested ingredients in the food supply. The ADI has a built-in safety factor and represents an intake guideline for every day over a lifetime. Tests with humans consuming much greater levels of aspartame than the ADI have shown no harmful side effects.

Even with the many unsolicited complaints to the FDA concerning aspartame, the FDA supports the safety of aspartame for the general population, including diabetics and pregnant and nursing women. As noted earlier, however, persons with a rare hereditary disease known as phenylkeuonuria (PKU) must control their phenylalanine intake from all sources, including aspartame.

Acesulfame-K

Acesulfame-K was approved by the FDA in July 1988 as a free-flowing tabletop sweetener and for use in dry-base beverage mixes, puddings and desserts, and chewing gums. The "K" refers to potassium. Acesulfame-K is about 200 times sweeter than sucrose. Several beverage companies use acesulfame-K and it's marketed under the names of Sunett® and Sweet One®.

Acesulfame-K is heat-stable and can be used in baking. Acesulfame-K helps foods sustain their sweetness over time, thereby increasing the sweetness shelf life of products. Foods containing blends of acesulfame-K contain up to 40 percent less total sweetener. This sweetener often is blended with other low-calorie sweeteners to produce a more sugar-like taste than of any of the low-calorie sweeteners alone.

The FDA has set the ADI for acesulfame-K at 15 mg per kg of body weight. Acesulfame-K does contain potassium, but at a lower level than that found naturally in foods. Although it contains sulfur, the structure of sulfur is different from that of sulfites and sulfa drugs, which have been shown to cause allergic reactions.

Sucralose

Sucralose was approved by the FDA in April 1998 and is sold under the trade name Splenda®. It is the only non-nutritive sweetener made from sucrose and is about 600 times sweeter than sugar. Sucralose has been approved for use in baked goods, milk products, salad dressings, processed fruits and fruit juices, and as a tabletop sweetener. Products made with sucralose maintain their sweetness during cooking and baking and in storage for long periods.

Neotame

Neotame was approved for use by the FDA in 2002. Neotame is composed of two amino acids — aspartic acid and phenylalanine — with an additional molecule of 3,3-dimethylbutyaldehyde. It is 7,000 to 13,000 times sweeter than sucrose and 30 to 60 times sweeter than aspartame. Neotame is not significantly metabolized to phenylalanine; therefore no warning label is required. It was approved as a general-purpose sweetener in products other than meat and poultry. It is also heat-stable and can be used in baked products.

Rebaudioside A

Rebaudioside A was approved by the FDA for use as a sweetener in 2008. Before 2008, it could only be sold as a dietary supplement. Rebaudioside A is a purified derivative of the plant stevia and is sold under the names of PureVia® and Truvia®.

Cyclamates

Cyclamate is a nonnutritive sweetener 30 times sweeter than sugar and complements other low-calorie sweeteners. When used with other low calorie sweeteners, cyclamate has a synergistic effect and reduces the total amount of sweeteners needed. It was discovered in 1937 and is approved for use in foods and beverages in more than 50 countries, including Canada, Australia and Mexico. It was banned in the United States in 1970 but a petition to re-approve cyclamate is under review by FDA.

Summary

Sweetener terminology can be confusing because there are so many kinds of sweeteners. See *Table II* for a complete list of terms.

Table II. Glossary of terms.

Sweetener	*Definition*
Agave nectar	A sweetener produced from several species of the agave plant. Also referred to as agave syrup.
Brown sugar	Sugar crystals containing molasses are added to refined white sugar — mainly pure sucrose.
Cellulose	The polysaccharide found in plant cell walls. Also known as insoluble fiber.
Dextrose	Also called glucose or blood sugar. One of the simplest forms of carbohydrate.
Fructose	Also called levulose or fruit sugar. A monosaccharide especially abundant in fruits.
Glucose	Also called blood sugar or dextrose. A monosaccharide found in nearly all plant foods.
Glycogen	A polysaccharide formed in the body from glucose and stored in the liver and muscle tissue.
Granulated sugar	Commonly known as table sugar or sucrose.
Lactose	Sugar found in milk.
Molasses	A dark colored liquid formed during the processing of sucrose. Blackstrap molasses is a byproduct of the final molasses crystallization step from sugar cane. Blackstrap molasses may contain iron if processed by iron machinery.
Non-nutritive sweetener	Current term for artificial sweetener. A manufactured sweetener that requires FDA approval to be marketed in the United States also may be referred to as an alternative or artificial sweetener.
...-ose	When a term ends in "-ose", it is usually a sugar.
Phenylketonuria	A genetic disease in which the body cannot produce the enzyme necessary for the body to use phenylalanine. This condition in children causes mental retardation if foods containing phenylalanine are consumed.
Powdered sugar	A sugar product produced by grinding a mixture of granulated sugar and cornstarch. Also referred to as confectioners' sugar.
Sucrose	Commonly known as table sugar, cane, or beet sugar. A disaccharide composed of glucose and fructose.
Sugar alcohols	Sorbitol, maltitol, mannitol, and xylitol
Turbinado	A semi-refined sugar that has undergone about half of the refining steps and has been washed to remove dirt.
White sugar	Also referred to as table sugar or sucrose.

Moderation and variety are always good words of advice to follow and applicable to the use of sweeteners.

Consumers should be aware of the benefits of moderate sweetener use, as well as the hazards of excessive use.

Using a variety of sweeteners will reduce your chances of ingesting significant amounts of any individual sweetener.

If you have any questions about the use of artificial sweeteners, contact the manufacturing company listed on the label.

Sugar is linked to issues in dental health.

Resources

American Heart Association, "Sugars and Carbohydrates": *http://www.americanheart.org/presenter.jhtml?identifier=4471*

American Diabetes Association, "Other Sweetening Options" *http://www.diabetes.org/food-and-fitness/food/what-can-i-eat/other-sweetening-options.html*

Canadian Diabetes Association, "Sweet Choices": *http://www.diabetes.ca/about-diabetes/nutrition/sweeteners/*

This publication has been peer reviewed.

Index: Food and Nutrition
Nutritive Value of Foods
2002, Revised May 2010

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