

Sugar and Sweeteners

Fact Sheet No. 9.301

Food and Nutrition Series | Health

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One of the earliest references to sugar in history is a Spanish drawing of a man harvesting honey, dated around 7000 B.C. We know that the Egyptians kept bees for honey, as depicted in tomb drawings as early as 2600 B.C. Research proves something that most of us are already aware of; people are born with a desire for sweet taste.

Sugars are widespread in nature and are the building blocks of carbohydrates. Sugar is naturally found in many foods, including milk, grains, fruit, and vegetables. The sugar found in these foods provides an important fuel source. Certain tissues in the body, such as the brain and red blood cells, exclusively use sugar for energy. Furthermore, these carbohydrate-rich foods provide a variety of other nutrients, such as fiber, vitamins, and minerals.

Sugar is also added to many foods, such as breads and other baked goods, cereals, flavored yogurt, sweetened beverages, and sauces. Many foods with added sugar provide energy (calories) but contain few other nutrients. They may replace other foods that are high in vitamins, minerals and other important nutrients in the diet. Therefore, it is important to moderate the consumption of these foods.

The World Health Organization recommends consuming no more than 10% of daily calories from added sugar and 'free sugars,' such as honey, syrup, or juices. High consumption of added sugars has been linked to certain illnesses such as obesity, diabetes, and heart disease. Therefore, it is important to consume them in moderation.

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Metabolism and Digestion

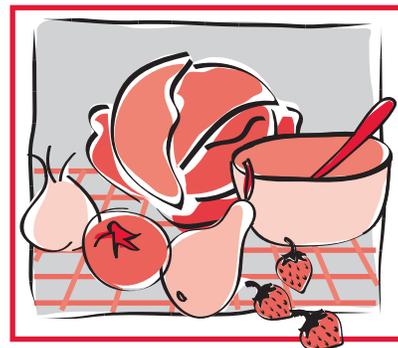
Although carbohydrate digestion starts in the mouth, the small intestine is the major area of digestion and absorption. Here, carbohydrates are broken into individual sugar molecules, or monosaccharides, such as glucose, fructose, galactose, and glucose- the most common sugar found in naturally occurring foods. Once broken down to monosaccharide form, the molecules are absorbed into the blood for transport throughout the body.

Energy needs of the body determine if the glucose will be shipped out to the brain, muscles, kidneys or heart for immediate use, or stored for later energy needs. In the liver or skeletal muscles, glucose can be stored as branched chains called glycogen. Glucose that exceeds immediate energy needs and glycogen storage capacity is converted to fat and stored in adipose tissue.

Regardless of its food source, glucose is always digested in the same manner. However, simple carbohydrates are digested more quickly than complex carbohydrates, which can lead to a more dramatic increase in blood sugar levels.

When metabolized for energy, all sugars contribute four calories per gram. Some foods contain more concentrated sources of calories than others. For example, a teaspoon of table sugar contains 16 calories. Honey is a denser calorie source - a teaspoon contains 22 calories. However, a teaspoon of orange juice or applesauce has just four calories, and also contains vitamins, minerals, and fiber.

It is important to note that fructose and glucose are metabolized differently. Fructose is metabolized primarily in the liver, and so it does not lead to a significant increase in blood sugar levels. As a result of this fact, products high in fructose, such as agave, were proposed as a good sugar alternative for individuals looking to manage blood glucose levels. However,



Quick Facts

- The desirable taste for sugar is innate.
- The body does not distinguish between natural sugars and processed sugars.
- All sugars contain four calories per gram.
- In 2002, the average American consumed 152 pounds of sugar per year.
- Sugar is natural and nontoxic. When eaten in moderation, it can be part of a balanced diet.
- Excessive consumption of sugar has been shown to cause tooth decay. It has also been linked to obesity, heart disease, hypertension, diabetes, and certain cancers.

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recent research has suggested that consumption of high levels of fructose may be detrimental, because the liver is unable to regulate its metabolism in the same way it can regulate glucose metabolism. Excessive fructose consumption may be associated with non-alcoholic fatty liver disease. It may also lead to increased risk for obesity and visceral fat, as well as increased dysregulation of lipids in the body and decreased insulin sensitivity. These factors have been linked to an increased risk for cardiovascular disease and type 2 diabetes.

Sweeteners

Sweeteners are prolific in the American food system, found in everything from candy to crackers to soups and salad dressings. The sugars and sweeteners listed below come from naturally occurring sources. However, in some circumstances a great deal of refinement may occur to form the final product.

Table Sugar

Table sugar is made of a type of sugar called sucrose, and is regularly produced from beets or sugar cane. Sucrose is composed of the two simple sugars, glucose and fructose. It is the most abundant sugar in nature, important for its palatability, availability, low cost, and simplicity of production. Additional products resulting from the refinement process of sucrose are molasses, brown sugar, and confectioners' sugar. Table sugar is highly processed and refined.

Molasses

Molasses is formed during the production of table sugar. It is the heavy dark liquid portion remaining after sugar is extracted from beet or sugar cane through crystallization. Molasses can vary in grade, depending on which extraction it is harvested from. Molasses obtained after only one extraction is sweeter and lighter in color because more sugar remains in the solution. Blackstrap molasses is formed during the third extraction of cane sugar. It is comprised of 55% sucrose, and is significantly less sweet. Therefore, it is commonly used in industrial production or as an ingredient in animal feed.

Honey

Honey is produced by honeybees, formed from nectar, and is composed primarily of sucrose. It has antimicrobial properties and can be a good source of antioxidants. However, the composition of honey can vary significantly from region to region, due to the variation of plants present. Processing can also greatly affect the quality of honey.

Some manufacturers produce artificial honey, made from beet or cane sugar. These products are more uniform in flavor and color, but lack the antimicrobial and antioxidant properties of pure honey.

It is important to note that honey may harbor spores of the bacteria that causes Infant Botulism, *Clostridium botulinum*. Therefore, honey should NEVER be given to any child under the age of one.

Maple Syrup

Maple syrup is made by cooking down the sap from maple trees. The sap of a maple tree contains 5% sucrose, with the remainder being comprised of other sugars, known as oligosaccharides. It takes approximately 40 gallons of maple sap to make 1 gallon of maple syrup. When it is condensed into the syrup form, it is made of 88-99% sucrose. A serving of maple syrup offers various vitamins and minerals, including calcium, potassium, and trace amounts of B vitamins, manganese, magnesium, and zinc.

Agave Nectar

Agave nectar is not truly a nectar, but is actually made from the heart, or base, of the agave plant. To form agave nectar, agave juice is processed, breaking down the carbohydrates into simple sugars. Agave nectar is comprised of mostly of fructose. Therefore, it was previously touted as a healthy sweetener, due to the fact that it does not raise blood glucose levels, or trigger insulin release. However, as previously mentioned, recent evidence suggests that when consumed in excess, high fructose levels may actually be detrimental to health, leading to decreased insulin sensitivity and increased abdominal fat.

Corn Syrup

Corn syrup is a glucose derivative of corn starch, popular in the brewing, canning, and baking industries because it

lends texture and body to these types of products.

High-fructose corn syrup (HFCS) takes the processing of corn syrup one step further, by converting some of the glucose to fructose. The resulting product is sweeter than sucrose, allowing less of it to be used. HFCS is the main nutritive sweetener in the soft drink industry, and constitutes 55% of the sugar consumed in the US.

Artificial Sweeteners and Sugar Substitutes

Sugar substitutes are food additives that are sweet yet contain significantly less calories than sugar. These substitutes may be derived from natural or synthetic sources. Naturally occurring sugar substitutes include stevia and sugar alcohols.

Artificial sweeteners are typically calorie-free and at least 30 times sweeter than sucrose. There currently are six alternative sweeteners approved for use in the United States: saccharin, acesulfame-K, sucralose, aspartame, neotame, and advantame. Cyclamates were considered safe for use at one time in this country, but were banned in the 1970s.

Many people question the safety of artificial sweeteners. However, at this time there is no scientific evidence that they pose a risk to human health. Excessive consumption of artificial sweeteners can cause undesirable side effects, however, including diarrhea and headaches.

Observational studies have noted that consumption of artificial sweeteners is associated with higher weight status. However, this could be due to the fact that non-caloric sweeteners are consumed in greater quantities by individuals who are overweight or obese. Subsequent studies have examined the effect of artificial sweeteners on various mechanisms that could cause weight gain, including insulin and neurological signaling, showing that these sweeteners interact differently with hormonal and neurological pathways than caloric sweeteners. Some studies have shown that artificial sweeteners may contribute to weight gain and associated health issues. However, evidence is inconclusive at this time, and the use of non-caloric sweeteners is still supported by numerous reputable organizations, including the

Academy of Nutrition and Dietetics and the American Diabetes Association.

Saccharin

Developed in 1878, saccharin is a coal tar derivative that is approximately 200-700 times sweeter than sucrose. It is sold as a white powder for use as a table-top sweetener, and used in a variety of foods such as beverages, jams, and baked goods. It is sold as Sweet 'N Low, Sweet Twin, and Necta Sweet. It has a bitter aftertaste at high concentrations.

In 1977, a warning label was placed on Saccharin, due to the fact that it was linked to bladder cancer in rats. Further research concluded that the mechanism by which the sweetener was causing tumors was not pertinent to human physiology, and in 2000 the warning label was repealed. Saccharin remains an FDA-approved sweetener.

In some individuals, saccharin can cause allergic reactions, resulting in symptoms such as headaches, skin problems, diarrhea, and breathing difficulties.

Aspartame

Commercially available as Equal, NutraSweet and Sugar Twin, aspartame is composed of two naturally occurring amino acids (the building blocks of protein) - phenylalanine and aspartate. Aspartame has a flavor similar to sucrose, and also functions as a taste intensifier and enhancer. Aspartame is 200 times sweeter than sucrose and has no aftertaste. After nearly two decades of safety testing, aspartame was approved by the FDA in 1981 for use in a variety of products, as a table-top sweetener and in carbonated beverages. In July 1993, aspartame was approved for use in hard and soft candies, baked goods and mixes, nonalcoholic beverages and malt beverages. A packet of this sweetener is equivalent in sweetness to two teaspoons of sugar (32 calories), for just four calories.

Products that contain aspartame must carry a warning to people with phenylketonuria, a rare genetic disorder that prevents proper metabolism of phenylalanine, an essential amino acid. Unlike other artificial sweeteners, which have no nutritional value, aspartame contributes calories. This is due to the fact that it can be used by the body just as any other protein, but the amounts are so

small that its caloric value is insignificant. Aspartame does not contribute to tooth decay.

Acesulfame-K

Acesulfame-K is similar to aspartame in sweetening power, but holds up better to heat and costs less. Marketed as Sunette, Sweet One and Sweet & Safe, the sweetener was approved by the Food and Drug Administration (FDA) in 1988 for limited use in products such as chewing gums and dry beverage mixes. In 1998, the FDA approved acesulfame K for use in soft drinks, and it was approved as a general sweetener in 2003. It is stable when heated and can be used in baking.

Sucralose

Approved by the FDA in 1998, sucralose is the only alternative sweetener made from sugar. It is 600 times sweeter than sucrose (1.6 calories per teaspoon). Sucralose is derived from sugar through a patented, multi-step process that creates an extremely stable substance unable to be absorbed by the human body, hence contributing almost no calories. It is excreted in the urine virtually unchanged. Manufactured under the name Splenda, sucralose can be found as a tabletop sweetener and in a variety of products including desserts, confections, and nonalcoholic beverages. Sucralose does not contribute to tooth decay.

Neotame

Neotame is 7,000 to 13,000 times sweeter than sugar. It was approved for use as a general-purpose sweetener by the FDA in 2002. Neotame contains phenylalanine. However, the product is used in such small amounts that it's negligible in the body. Currently, neotame is rarely used in food.

Advantame

The FDA approved the use of advantame in the US in 2014. This sweetener is chemically similar to aspartame, and it contains phenylalanine. However, unlike aspartame, foods with this sweetener are not required to carry a warning label for people with phenylketonuria. Advantame is 20,000 times sweeter than sucrose, as opposed to aspartame, which is only 200 times sweeter. Therefore, a significantly smaller

dose of advantame is needed to sweeten foods, and a warning label is not needed. Advantame has been approved for use in non-alcoholic beverages, chewing gum, and certain foods.

Cyclamates

Cyclamates are 30 times sweeter than sugar, leave little aftertaste, and are heat stable. Cyclamate was banned in the U.S. in 1970 after a study where it was fed to rats in combination with saccharin implicated it as a possible cancer-causing agent. (Subsequent research failed to replicate this finding.) Cyclamates have been pending re-approval by the FDA since 1982, and are approved for use in 50 other countries including Canada. Use of cyclamates in Canada is restricted to table-top sweeteners and pharmaceuticals.

Sugar Alcohols

Sugar alcohols are sometimes used as a substitute for sucrose. Mannitol, sorbitol, and maltitol are all sugar alcohols that occur naturally in fruits. Xylitol is a normal intermediate product in the metabolism of carbohydrates in fruits and vegetables. While sugar is typically found in a ring structure, sugar alcohols are not. They are reduced-calorie sweeteners, contributing 1.5-3 calories per gram, as opposed to 4 calories per gram for sugar.

Sugar alcohols add bulk and texture to food such as hard candies. They do not contribute to tooth decay, so they are commonly found in chewing gum. They are metabolized by the body more slowly than sucrose and have a lesser effect on blood glucose levels. Therefore, they are used in foods created for individuals following special diets, such as a diabetic diet.

Stevia

Stevia is 250 times sweeter than sucrose. It is processed from a compound found in the leave of the stevia plant. Stevia has a bitter taste when consumed in high quantities and is shelf-stable when dry. It is approved for use in various food products, including cereals, beverages, and energy bars, as well as a tabletop sweetener.

Sugar and Your Health

Obesity

Excessive consumption of calories, regardless of their source, can lead to weight gain and obesity. It is unlikely that any one food group is responsible for this complicated metabolic state. However, sugar offers “empty” calories, devoid of other nutritional benefits. By reducing the amount of sugar, and thus calories, in your diet, it is possible to lose weight without compromising intake of essential nutrients.

Additionally, eating foods with significant sugar content can create large swings in blood glucose, leading to subsequent overconsumption of food. Furthermore, multiple studies have examined the reward pathways associated with sugar consumption, noting that it is possible that sugar may be an addictive substance for some individuals. This may further contribute to overeating, leading to excessive weight gain.

Diabetes

Data from multiple studies suggests that the consumption of sugar-sweetened beverages may increase risk of developing diabetes. Approximately half of the US population consumes sugar sweetened beverages each day.

Some studies have observed an association between the consumption of high glycemic index foods, such as sugar, and the development of type 2 diabetes. However, findings on this matter have been inconsistent, so the issue remains unclear at this time. Nonetheless, one of the biggest risk factors for type 2 diabetes is being overweight or obese. Reducing sugar consumption can aid in healthy weight loss, which can be very beneficial for individuals with prediabetes or diabetes.

It is crucial to monitor sugar intake to successfully manage diabetes. Sustained elevated blood sugar can cause a myriad of health concerns, including the vision loss, kidney problems, neuropathy, and circulation issues. A balanced diet and regular physical activity can be very advantageous for the management of this condition.

Cancer

High sugar consumption is associated with an increased risk for certain cancers, including colorectal cancer, pancreatic cancer, and endometrial cancer.

Additionally, excess sugar consumption is a risk factor for obesity. In cancer patients, obesity is linked to poorer treatment outcomes and increased mortality. Moreover, obesity is associated with increased risk for certain cancers, including postmenopausal breast cancer, pancreatic cancer, and cancer of the liver.

Heart Disease

Research has shown that high consumption of added sugar has been linked to higher risk for cardiovascular disease. It has consistently be linked to stroke, high blood pressure and elevated blood lipid levels. The American Heart Association recommends limiting added sugar consumption to 100 calories a day for women, and 150 calories for men. Decreasing sugar consumption can improve blood cholesterol and triglyceride levels, decreasing risk for heart disease.

Tooth Decay

Sugars and starches are major contributors to tooth decay. Risk for developing dental caries (cavities) increases with the frequency of consumption of foods with sugar and the longer they remain in the mouth without brushing the teeth.

Sugars in the mouth are digested by bacteria on the tooth’s surfaces. Acid produced by the bacteria causes the enamel to break down, leading to cavities and gum disease. Sugar that remains on the teeth is actually of more concern than amount of sugar consumed. The acid produced by the bacteria lasts for about 20 minutes each time carbohydrate is eaten. This is true regardless of which carbohydrate-containing food is eaten. Bacterial acid production is present whether the carbohydrate is glucose from concentrated sweets, starches, lactose from milk, or fructose from fruit. The stickiness of the sugar also supports bacterial growth.

Oral health can be promoted by limiting between-meal snacks (especially those high in sugar or starch), brushing with fluoride toothpaste, and flossing

regularly. Ask a dentist about fluoride supplements, especially for children.

Limiting Sugar Intake

Consuming sugar in moderation can promote health and help maintain healthy body weight. There are a number of ways to reduce sugar intake. Learn to enjoy foods that are naturally sweet, without added sugar. Below are shopping and cooking suggestions to help meet the Dietary Guidelines’ goal of using sugars in moderation.

Shopping:

- Take the time to read labels and review the information on the overall nutritional value of foods. Carefully check the ingredient list for added sugars. See Table 1 to review the many names under which sugar can be listed.
- Buy fresh or frozen fruits. When purchasing canned products, choose fruit packed in water.
- Buy fewer foods high in sugar such as cookies, candies, soft drinks, and prepared baked goods.
- Be careful not to replace foods high in sugar with foods high in fat and sodium.

In the kitchen:

- Use 2/3 to 3/4 cup of sugar for each cup in a recipe.
- Replace omitted sugar with an equal amount of non-fat dry milk to increase nutritional value.
- Use spices and herbs such as cinnamon, nutmeg, cloves and ginger to enhance the flavor of foods.
- Make homemade sauces and dressings, such as barbeque sauce, pasta sauce, salad dressing, or whipped topping, which often have less sugar than store-bought packaged versions.
- Use dried or fresh fruit to sweeten cereals and baked goods instead of table sugar.

Snacks:

- Try unsweetened, low-fat yogurt flavored with nutmeg, cinnamon or fresh fruit.
- Eat popcorn, raw vegetables or low-fat cheese instead of cookies and candy.
- Swap graham crackers or vanilla wafers for chocolate chip cookies.
- Top cakes with fresh fruits instead of frosting.
- Drink water or unsweetened sparkling and mineral waters, instead of Kool-Aid, fruit flavored drinks, or soda pop.

Food Labels

The Dietary Guidelines advise to consume sugar only in moderation, but much of the sugar in our diets is hidden, as it is already added to the foods we eat. By reading food labels and becoming more aware of the sugar content of every day foods, it is easier to reduce the total amount of sugar in our diets. Food labels list ingredients in order of amount present in the food, from most to least. If sugar is listed as one of the first three ingredients, the product is considered high in sugar.

Some foods contain several different types of sugar in various forms. Table 1 lists different types of sugars.

Table 1: Types of Sugars

Anhydrous dextrose	Beet Sugar	Brown rice syrup	Brown Sugar
Cane juice	Cane sugar	Confectioner's Sugar	Corn Sweetener
Corn syrup	Corn syrup solids	Date sugar	Dextrose
Fructose	Fruit juice concentrate	Galactose	Glucose
Granulated sugar	High fructose corn syrup (HFCS)	Honey	Invert sugar
Lactose	Malt Syrup	Maltose	Maple syrup
Molasses	Nectar	Sucrose	Turbinado

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