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The SKINNY on SWEETENERS

How Do They Work?

By Christen Brownlee

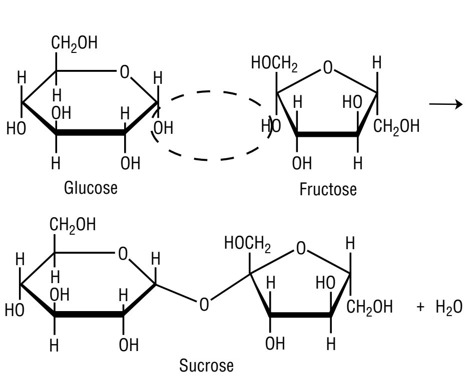
According to the U.S. Department of Agriculture, Americans consume an average of 156 pounds of sugar each year. That's a little more than 31 of the five-pound bags you might see in the baking goods aisle in the grocery store! We all know that eating too much sugar can cause tooth decay, weight gain, and type-2 diabetes, but is there a way to indulge your sweet tooth and still avoid sugar? Yes. Food and beverages labeled "diet" taste sweet yet don't contain sugar—thanks to artificial sweeteners.

Why do artificial sweeteners have no calories? Could they be bad for your health? Let's compare the chemistry of sugar and artificial sweeteners to find out.

Better than sugar?

First, let's look at table sugar. It belongs to a family of molecules called carbohydrates that are found in fruits, vegetables, dairy products, breads, and sweets. Carbohydrates are made of many repeating units that are composed of carbon, hydrogen, and oxygen.

Table sugar, or sucrose, is made of two units. These two units, called glucose and fructose, are combined to produce sucrose as follows:



Carbohydrates are an excellent fuel for the body because they are packed full of energy. They are broken apart first in your mouth and then in your small intestine. The resulting molecules enter the bloodstream and travel to cells, where they are used to release energy.

But sucrose can have two negative health effects. First, when we eat food or drink beverages that contain sucrose, bacteria that live in our mouths also use sucrose as an energy source and produce acid that contribute to tooth decay.

Second, when we eat or drink too much sucrose, the amount of insulin in our blood spikes. Insulin is a hormone that regulates the amount of sugar in our blood. Over time, too much insulin in the blood can lead to diabetes, a medical condition characterized by unusually high blood sugar levels.

Chemists have been trying to find alternatives to sugar since 1878—that's the year that an American chemist named Constantin Fahlberg discovered saccharin, the first artificial sweetener currently known by the brand names Sweet'N Low and SugarTwin.

Saccharin is actually sodium 3-oxobenzisosulfonazole ($C_6H_4SO_2CONNa$), a molecule that has little in common with sucrose but is much sweeter than sucrose. Also, the digestive system does not break it apart to derive energy the same way it does with sugar. Instead, saccharin dissolves into the bloodstream and is flushed out of the body in urine. Saccharin is now used to sweeten countless products, including drinks, candies, biscuits, and medicines

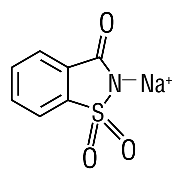


Figure 1. Chemical structure of saccharin, an artificial sweetener.

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Sweet aminos

Not all artificial sweeteners look like saccharin. Aspartame, known by the brand names NutraSweet and Equal, is the primary sweetener in most diet sodas. It is a combination of amino acids, the building blocks of proteins—organic compounds found in meat, eggs, milk, and legumes. A protein is a molecule made of a chain of repeating units of amino acids.

The structures of two amino acids, aspartic acid and phenylalanine, are shown in Fig. 2. Aspartame (Fig. 3) consists of a combination of these two amino acids.

While saccharin tastes sweet, it also has a lingering bitter and metallic taste that some people can detect. That makes it a good choice for sweetening tea and coffee, which have their own bitter taste, but not necessarily a good one for candies and soft drinks, which are known to be sweet. Aspartame does not have a bitter taste, which makes it a better choice for a wide variety of sweet foods and drinks.

Unlike other artificial sweeteners, aspartame is metabolized in the body, so aspartame is higher in calories. But aspartame is 180 times sweeter than sugar, so it can be used in small quantities and, as a result, does not generate as many calories as sucrose.

Another popular artificial sweetener is sucralose (brand name: Splenda). Its chemical structure is similar to that of sucrose (Fig. 4),

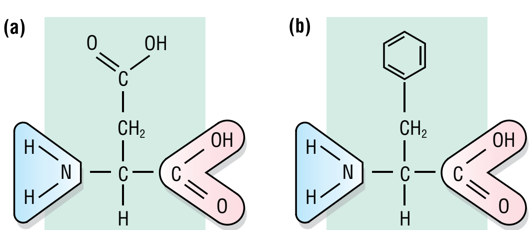
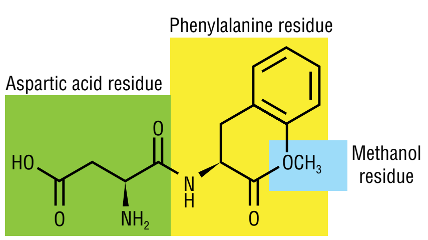


Figure 2. Examples of two amino acids: (a) aspartic acid and (b) phenylalanine. Like all other amino acids, aspartic acid and phenylalanine consist of three parts t hat bind to a central carbon: and amino group (–NH₂), a carboxyl group (–COOH), and a side chain (middle) that varies depending on the amino acid.



Aspartame (Nutrasweet, Equal)

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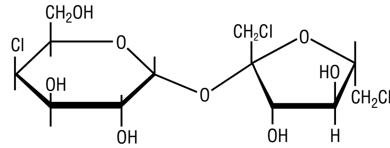
Figure 3. Chemical structure of the artificial sweetener aspartame



Sucralose

Figure 4. The chemical structure of sucralose is similar to the structure of sucrose.

but like saccharin, sucralose has no calories. It is washed out of the body without being digested. Sucralose is 600 times as sweet as sucrose, about three times as sweet as aspartame, and twice as sweet as saccharin.

Table 1 summarizes the relative sweetness of common artificial sweeteners compared to sucrose.

Sweet Substance	Brand name	Relative Sweetness
Sucrose	none	1
Glucose	none	0.7
Fructose	none	1.3–1.8
Saccharin	Sweet'N Low, SugarTwin	300
Aspartame	NutraSweet; Equal	200
Sucralose	Splenda	600

Table 1. Relative sweetness of artificial sweeteners compared to sucrose

Any risks to human health?

Over the years, concerns have been raised that several artificial sweeteners may cause health problems. In theory, artificial sweeteners should be safe because they pass easily through the digestive system without being processed. But scientific tests were needed to confirm that artificial sweeteners were indeed safe.

In 1977, rats that were fed saccharin developed bladder cancer. The rats, however, had to eat an amount of saccharin comparable to a human drinking hundreds of cans of soda each day. As a result, Congress required that all food containing saccharin display the following label: *"Use of this product may be hazardous to your health. This product contains saccharin, which has been determined to cause cancer in laboratory animals."* Subsequent studies could not find evidence that saccharin causes cancer in humans. It is now used in food and drinks all over the world.

In 1996, studies suggested that aspartame may cause brain tumors because the number of people with brain tumors had increased over the years after aspartame was introduced on the market. Further studies, however, revealed that brain cancer had started to rise 8 years before aspartame was made publicly available. No other studies have since shown a correlation between aspartame use and cancer.

Many other artificial sweeteners have been tested. None of these tests has provided clear evidence of an association with cancer in humans. So, avoiding too much sugar or artificial sweeteners might be beneficial to health and be just what the doctor ordered! CM

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