

The Skinny about “Non-Caloric” Sugar Substitutes

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Bottom Line at the Top: There really is no bottom line, since they are all different. I'll discuss Sweet 'N Low, Splenda, Sunette, Stevia, Naturlose, Neotame and Equal/Nutrasweet, with most detail about the latter, since it is the most maligned.

Some consider sugar substitutes an essential food group - a guilt-free, sweet-tooth appeaser. To others, they are the root of all medical maladies. While the debate rages, I can only give you some facts.

First, most 'zero' calorie sweeteners fib a bit about being calorie-free. Aspartame, neotame and the fraction of tagatose that is absorbed into the body supply 4 calories per gram. Many low or non-caloric sweeteners contain bulking agents that supply a few calories. Companies add these to give the few milligrams of sweetener the texture of sugar and enough bulk to know that something has come out of the packet.

However, the sweeteners are so sweet that a one-gram 'serving' rarely contains more than 50 milligrams of sweetener and all contain less than 1 gram of bulking agent. The packet can claim no calories because any food product with less than 1 gram of protein, sugar or fat *per serving* does not have to list those calories on the label.

Back to the debate: The first non-caloric sweeteners seemed to vindicate their foes. Cyclamate, once a popular sugar substitute, was banned by the U.S. Food and Drug Administration (FDA) in 1970 because it causes cancer. For many years saccharin carried a cancer-related warning label because large amounts caused bladder cancer in rats.

Sugar substitutes made a come-back with a slew of new ones approved by the FDA. The FDA determined that saccharin was safe in humans and removed its cancer-related warning label in 2000.

Saccharin, marketed as **Sweet 'N Low**, was synthesized in the 19th century from chemicals. It tastes 300-500 times sweeter than sugar and is widely used in tabletop sweeteners, diet sodas and baked goods, but has an aftertaste. The bitter aftertaste of saccharin is often minimized by blending it with other sweeteners.

Saccharin causes bladder cancer in male rats by a non-mutagenic mechanism that does not occur in humans. Cancer results from damage to the bladder wall caused by an interaction between saccharin and rat urine. Human urine is different enough that the cancer-causing interaction does not occur. Most countries permit saccharin but restrict use, while a few countries have continued the ban.

Each 1 gram packet of Sweet'N Low contains 30 mg saccharin and nutritive dextrose, cream of tartar and calcium silicate for bulk, color and texture.

Aspartame, sold as Equal and Nutrasweet, dominates the world low-calorie sweetener market with 44% market share. It was discovered as a novel sweetener in 1965 and transiently entered the U.S. market in 1974, but the FDA suspended use for further safety testing. When no link to cancer or disease was found, the FDA approved use in solid food in 1981 and soft drinks in 1983.

Aspartame is 200 times sweeter than sugar. An international committee of experts set the acceptable daily intake of aspartame at 40 [mg/kg body weight per day](#). For a 150 pound person, that would be 68 packets of Equal daily. Sounds bizarre, but some people do it.

It's hard to tell how much you have consumed, because many products sweetened with low/non-caloric sweeteners don't tell you how much is in them. They don't have to if the quantity is less than a gram and a 1 gram (1000 mg) Equal packet contains only 40 mg of aspartame. The other 960 mg is maltodextrin and nutritive dextrose.

Aspartame is basically two amino acids (natural protein building blocks) linked to each other and methanol. The body metabolizes the amino acids as protein, supplying 4 calories per gram, but aspartame is so sweet you can get your sweet fix for a fraction of a calorie.

People have worried that aspartame causes disastrous health problems because of its breakdown products. Whether or not aspartame spontaneously breaks down in food and beverages depends on its exposure to acid, heat and water. It is very stable as a dry powder, when frozen or dissolved in a moderately acidic solution at room temperature. The dry powder tolerates high heat.

In solutions outside aspartame's stable pH range (3.4 – 5), it degrades to its two component amino acids and methanol. Some sodas have a pH lower than the stable range allowing aspartame to degrade very slowly at room temperature, and much more quickly if stored above body temperature.

Pre-consumption degradation leads to loss of sweetness, but doesn't affect the body, because our stomach acid and digestive enzymes completely break aspartame down anyway. No aspartame is absorbed intact into the body. The amino acids and methanol are absorbed just the same as they would be if they had not come from aspartame.

Aspartic acid and phenylalanine mix in with all the other amino acids we get from food proteins. Theoretically aspartic acid might trigger certain brain receptors, but the human body disposes of aspartic acid so fast that blood levels don't rise even after large doses of aspartame.

Phenylalanine levels rise modestly after high aspartame doses, as they would with a meal. Initial fears that elevated phenylalanine levels might affect brain chemistry haven't panned out. It should not be used by people with phenylketonuria, a rare genetic disorder.

People worry most about aspartame's methyl group which converts to methanol, then to formaldehyde, and then to formic acid and CO₂. Formaldehyde is a carcinogen. Over 200 studies of aspartame's safety have not found that it causes cancer. That may be because of the very small quantities ingested, and the speed with which the body absorbs, breaks down and excretes methanol by-products.

Diet drinks generate less methanol than does fruit juice. Fruit or tomato juice contains 4-6 times more methanol than does an aspartame-containing diet drink. The body can't tell whether methanol comes from aspartame or fruit juice, so the outcome is the same.

Only a huge slug of aspartame (>50 mg/kg body weight) would produce detectable blood methanol levels. It takes a methanol [dose](#) of 200-500 mg/kg body weight to induce visual and nervous system toxicity, 50-100 times what people usually ingest.

Methanol in large amounts (as in grain alcohol) may cause headaches. Some people say that aspartame gives them migraines. That may be so, but well-controlled studies of people who believe they have aspartame-induced headaches find just as many headaches as with placebo.

More than 200 toxicological and clinical studies have been conducted over the past 30 years, almost all of which have confirmed the safety of aspartame. Regulatory agencies in 130 countries have reviewed aspartame and found it to be safe. Most scientific organizations that have weighed in on the question have come to the same conclusion, including the American Medical Association, the American Dietetic Association, the American Diabetes Association, and the American Cancer Society.

Neotame's structure is similar to aspartame, but is 7000-13,000 times sweeter than sugar and does not lose its flavor when cooked. Though not available as a table-top sweetener, the food industry uses it in diet shakes, dairy products, frozen desserts, gum and baked goods. It is FDA approved.

Sucralose, better known as **Splenda**, is the first artificial sweetener made from natural sugar (sucrose). The FDA approved it on April Food's Day, 1998. Sucralose has a key molecular structure that makes it similar to, yet different enough from sugar to be 600 times sweeter. It has no calories because we don't absorb most sucralose from the gut into our bodies and what little does enter the bloodstream leaves, unchanged, through the kidneys.

Though chemically related to sugar, it does not mimic sugar's taste. Splenda tastes different enough that diet sodas containing it have lost market share and were re-launched with aspartame. It does have sugar's texture and bulking properties that make it useful for baking and confectionery products. On average, humans consume 1.1 mg/kg/day of sucralose.

People claim to experience numerous adverse effects from sucralose, but they are not confirmed in randomized, controlled trials. There is a single proven and published report of sucralose causing migraine.

Since the body does not absorb sucralose, it may be fermented by gut bacteria, leading to abdominal pain, bloating, gas, and nausea. Large sucralose doses shrink mouse thymus glands and enlarge rat colons, but no cancer inducing, birth defect causing or nerve or brain toxicity effects have been seen in animals or humans.

Tagatose, also call **Naturlose**, is a naturally occurring sugar only partially absorbed by the human digestive system. Because much of it doesn't make it into the body, tagatose supplies fewer calories than regular sugar. It is a low (not zero) calorie sugar substitute, because the body metabolizes the fraction that the gut absorbs as if it were fructose, yielding 4 calories per gram.

Tagatose occurs naturally at low levels in heated cow's milk, other dairy products and the gum of *Sterculia setigera* (an evergreen tree). Bulk tagatose sweetener comes from chemically modified mild sugar. Because it is a naturally occurring sugar, the FDA has granted it "generally recognized as safe" (GRAS) status, without extensive pre-market testing. So far only 7-Eleven uses it in their Diet Pepsi Slurpees.

Tagatose's structure, sweetness and cooking properties are very similar to fructose. People with disorders of fructose metabolism should avoid it. People with metabolic syndrome should probably avoid it also (see DrG's MediSense, Vol 3-1 & 3-2.)

Stevia (Sweet Leaf or Honey Leaf) is short for *Stevia rebaudiana Bertoni*, a plant from Paraguay. It contains the natural sweeteners stevioside, rebaudioside A, B, C, D, & E, steviolbioside and dulcoside A. Stevioside is 300 times sweeter than sugar but provides no calories.

People use either the leaves or pure stevioside or rebaudioside extracts as food sweeteners. Manufacturers often combine stevia with fiber and sell it as a dietary supplement. Because it derives from a plant, the crude leaf is not subject to regulation by the FDA, even though we don't know the safety of whatever else is in the leaves.

Coca-Cola Co and PepsiCo are both rolling out beverage products sweetened with rebiana, shorthand for rebaudioside A. It supposedly tastes better than crude stevia. Food companies have asked the FDA to consider rebiana a dietary supplement with GRAS status. The FDA has not yet granted that status, or approved Cargill's non-calorie sweetener Truvia, made from stevia.

Short-term cooking does not affect stevia, but prolonged storage at body temperature degrades sweetness. Even more is lost with moderate heat in acid solution. Stevia has no after-taste.

Although stevioside has no mutagenic effect, a natural metabolite, steviol causes mutations in bacteria and rats. Metabolic degradation of steviol eradicates its cancer-causing potential. It is not clear to what extent the human body converts stevioside to steviol and how rapidly steviol disappears from the body.

Acesulfame K is a synthetic sweetener marketed as **Sunett** and **Sweet One**. Its stability when heated or dissolved in acid makes it suitable for use in cooking and in products with long shelf-life. Discovered accidentally in 1967 by a German food chemist, it is 180-200 times sweeter than table sugar.

Its bitter aftertaste has led Kraft Foods to combine it with sodium ferulate to mask the bitterness. Other food manufacturers blend it with other sweeteners to make it taste more like sugar and cut the aftertaste.

Critics of acesulfame K say the chemical has not been studied adequately and may be carcinogenic. The U.S. Food and Drug Administration and equivalent authorities in the European Union believe the safety data are compelling enough to allow its use.