

## Stevia's Sweet Story

By Lynn A. Kuntz, Editor-in-Chief

Stevia's history started in Paraguay, where the indigenous people used leaves of the plant known as *kaa he-he* ("sweet herb") to sweeten mate beverages and herbal teas, or chewed them for their sweet taste. A more-widespread awareness of its sweetening power started in the late 1800s to early 1900s. This led to its adoption by the Japanese as a natural high-intensity sweetener in the 1970s, when Morita Kagaku Kogyo Co., Ltd. commercialized its stevia sweetener and established an integrated production system from cultivation to extraction and refinement.

Fast-forward to 2010, when stevia-based sweeteners are approved for food use in a number of countries across the globe: Japan, Korea, China, Taiwan, Australia, Russia, Ukraine, Kazakhstan, Malaysia, Indonesia, Latin America and the United States. In April 2010, the European Food Safety Authority (EFSA) issued a positive opinion on the safety of steviol glycosides.

"The GRAS notification, GRN 252, received a 'no objection letter' from FDA, which made reb A (rebaudioside A) purity of more than 95% GRAS in the United States. A recent GRAS notification (GRN 287) asked for GRAS status of stevia extract containing more than 95% of total steviol glycosides and received a 'no objection letter' from FDA," explains Sidd Purkayastha, technical director, PureCircle Limited, Oak Brook, IL. Any other stevia products marketed here currently follow the self-affirmed GRAS route.

### How sweet it is

The plant that supplies the popular sweetener, *Stevia rebaudiana* Bertoni, belongs to the aster family, Asteraceae, and is one of 150 to 300 species of perennial herbs and shrubs. *Stevia* plants are cultivated today in Paraguay, Mexico, Central America, Japan, China, Malaysia and South Korea, as well as some parts of Europe.

*Stevia rebaudiana* produces a number of sweet compounds. The leaves contain a complex mixture of naturally sweet diterpene glycosides. These include stevioside (4% to 13% dry weight); steviolbioside (trace); rebaudiosides A (2% to 4%), B (trace), C (1% to 2%), D (trace) and E (trace); and dulcoside A

(0.4% to 0.7%), according to a 1999 EU safety review (“Opinion on *Stevia Rebaudiana* Bertoni Plants and Leaves”). “Dried leaf contains around 12% to 18% total steviol glycosides (TSG),” says Purkayastha. “Depending on the variety of stevia leaves, either stevioside or reb A is present in the highest quantity.”

The leaves also contain about 6.2% protein and 5.6% lipids on a dry-weight basis, as well as labdane diterpene, triterpenes, sterols, flavonoids and other compounds. The actual rebaudioside A (reb A) content of the leaves depends on the plant variety, cultivation, climate and associated factors.

The majority of stevia’s sweetness comes from the glycosides stevioside and reb A. Stevioside is about 200 times as sweet as sucrose, and tends to have a more-bitter and licorice-like taste, with a slower sweetness onset than sucrose. Reb A is about 300 to 350 times as sweet as sucrose, with less-objectionable bitter and licorice tastes than stevioside.

Typically, “Stevioside is the most abundant compound in the stevia leaf; it is also responsible for the strong bitter after-taste characteristic of crude stevia extracts,” says Cecilia McCollum, executive vice president, Blue California, Rancho Santa Margarita, CA. Reb A, a less abundant compound in the stevia leaf, at very high purity—ours is 99% pure— has a clean taste, no bitter after-taste, no metallic taste and is also very stable, making it an ideal natural sweetener for food and beverage.”

The actual sweetness of a specific stevia-based sweetener depends on its composition. “Most stevia extracts are only 200 times sweeter than sugar,” notes McCollum, with a 99% reb A extract being about “400 times sweeter than sugar.”

Stevia is used in different forms: fresh or dried leaves, extracts, and liquid concentrates. To minimize off-tastes and meet FDA no-objection GRAS levels, higher concentrations of reb A are in high demand. To create extracts, manufacturers use proprietary and/or patented techniques that typically begin with the dried leaf, which is extracted with water or an organic solvent, such as alcohol. These extracts undergo various refining steps to concentrate the sweet stevia glycosides, including processes such as precipitation of unwanted compounds with inorganic salts or changes in pH, or aggregation on polymers or fixed adsorbents. The extracts can be purified by techniques such as ion-exchange, chromatography, liquid extraction, electrophoresis and membrane filtration.

## Stevia, the healthy choice

The obvious benefit to stevia-sweetened products is the elimination of the extra calories sugar and other caloric sweeteners bring. But, stevia could provide other benefits.

“The health benefits of stevia are numerous,” says Jim May, founder, Wisdom Natural Brands, Gilbert, AZ. “However, each stage of the extraction offers different health benefits, right down to the combination of glycosides that are retained in the final sweetener product.” He notes the different varieties of stevia will also offer various benefits because the nutritional contents of the leaves will vary.

“The most scientifically researched of the leaves is the Criolla variety originally found in Paraguay,” continues May. “According to extensive research, this variety contains 100 different nutrients. The leaves and a dark liquid produced by cooking the leaves in water—thus retaining the total nutrient content—offer the most health benefits, including normalizing blood sugar and lowering high blood pressure, as well as killing various viruses and harmful bacteria. There are well over 1,200 published scientific studies pertaining to the safety and incredible health

### Stevia's Rising, But U.S. Still Sweet on Sugar

*According to a recently released report from Datamonitor, “The Future of Sweeteners: Consumer Insight and Product Opportunities,” U.S. consumer reliance on sugar and other caloric sweeteners is double the global average, accounting for 17.1% of their total energy intake. Germany and the Netherlands tie for second at 13.7%.*

*“As a source of energy, our love affair with anything sweet continues as we rely heavily on sugar and sweeteners,” notes Katrina Diamonon, consumer analyst, Datamonitor. “The United States is dependent upon sugar to keep going rather than more-nutritious foods such as cereals. U.S. energy from cereals is less than half that of the global average.”*

*U.S. consumers currently tend to focus more attention on cutting fat out of their diet rather than sugar. Some other countries have a much higher collective attention paid to the amount of sugar they consume. In the United Kingdom, 37% of consumers report that they pay a great deal of attention to the amount of sugar they consume. In Australia, that number climbs to 40%.*

*However, more U.S. consumers have begun basing product-purchasing decisions on nutritional criteria, with 51% using nutritional information on product packaging to make food and drink choices—a number that exceeds the global average of 44%. According to Datamonitor, this suggests consumers may be building awareness of their need to curb sugar intake and pay greater attention to nutritional choices.*

*As more people begin paying a higher degree of attention to the amount of sugar they consume, alternatives like stevia—a natural, calorie-free sweetener—are leading the way versus artificial sweeteners. As noted by Confectionerynews.com, Mintel has found that more than 100 stevia-containing products have been released in the United States this year—and progressively more are on the way. Mintel anticipates sales of stevia-sweetened products to hit \$2 billion by 2011.*

*However, stevia still faces an uphill climb as formulators work to mitigate off-flavor issues—and deal with its high price tag, something that can be attributed to its early stage of market development.*

benefits of stevia.”

Another potential nutraceutical use is to enhance brain function. A 2009 patent application by DSM, headquartered in Heerlen, the Netherlands has named stevia extracts and constituents, including steviol and stevioside, as well as rebaudiosides A to F, and other steviol glycosides, as active ingredients that will “improve cognitive functions, such as learning, memory and alertness, as well as relieving psychosocial pressure.” states the application. The animal research that led to the patent indicates stevia compounds may enhance cognitive function by interacting with a specific brain receptor that boosts synaptic transmission, or chemical signaling in the brain.

## Sweet applications

Stevioside and reb A are very stable to heat and pH above 2; the heat stability decreases somewhat in an acid pH. This makes them versatile, natural high-intensity sweeteners in many food applications, such as beverages, baked goods, confectionery products and sweet dairy products. “The first applications out of the gate have been tabletop sweeteners and flavored waters,” says Ronald C. Deis, Ph.D., vice president, applications research & technical services, Corn Products U.S., Newark, DE. “Our product has also worked well in frozen desserts, a number of bakery applications, and fruit-based beverages.”

Reb A “can interact with some ingredients in application to provide a slightly higher or lower level of

### Stevia, Aspartame Equal in Consumer Acceptance

*Consumers are just as likely to grab a stevia-sweetened product as they are to use the artificial sweeteners aspartame and sucralose, according to food and beverage market research conducted by The NPD Group. The NPD Group reported consumers’ acceptance of stevia in their diets is comparable to their intentions to consume products with the artificial sweeteners, noting this is remarkable because it is only two years after the U.S. Food and Drug Administration (FDA) approved the use of the natural sweetener stevia in foods and beverages.*

*NPD’s Dieting Monitor began tracking consumer attitudes about stevia in August 2009. According to June data from the most recent Dieting Monitor, 35 percent of U.S. consumers said they either already consume or would consider eating or drinking products or beverages that contain stevia. This compares to 39 percent of consumers who said the same for aspartame. Fifty-one percent of consumers said that they either already ate or would consider eating or drinking products or beverages that contain sucralose.*

*NPD noted stevia as a sugar substitute entered the market in 2009. Aspartame, which has recently been renamed “AmnioSweet,” has been in the marketplace for 15 years, and sucralose was introduced in 1999.*

sweetness,” notes Purkayastha. “Reb A is very stable for all thermal and pH conditions used in typical food processing.”

“In solution, the stability of steviol glycosides depends on pH, temperature and storage time,” explains John Fry, PH.D., principal consultant to Cargill, Wayzata, MN. The stevia sweeteners are accepted by JECFA as being “sufficiently thermally and hydrolytically stable for use in foods, including acidic beverages, under normal conditions of processing and storage”. However, it is worth noting that the key breakdown products of rebaudioside A are themselves potentially sweet, so even where this glycoside is somewhat degraded (e.g. by a combination of low pH and high temperature), there is generally insignificant sweetness loss. To put it in context, Rebiana (the common name for high-purity reb A extracts from stevia) is much more stable than aspartame, and rivals the stability of sucralose in most instances, including in baking.”

When exposed to light for long periods of time, stevia basically retains its sweetness. Deis cites studies run by The Coca-Cola Company, Atlanta, that “reported excellent stability of reb A and stevioside to light” (*Journal of Agricultural and Food Chemistry*, 2008; 56:8,507-8,513).

“There was some outdated work that suggested a light sensitivity. It was always difficult to understand how this might occur, as the stevia sweeteners have the wrong structure to behave this way. Work in the last couple of years has now comprehensively refuted the older study. Both rebaudioside A and stevioside are stable to light,” says Fry.

“High purity not only enhances the taste but also the sweetening power of reb A as well the stability,” says McCollum. “Taste, for example, will not degrade over the shelf life of the finished product, while steviol glycosides, normally with a high content of steviosides, taste and sweetness degrade faster. Reb-A is a very stable product and works very well in almost any type of food application from beverages to pastries, sauces, yogurts and even savory products.”

Reb A has synergies with a number of other sweeteners, according to Deis, and “most of these arise from complementary effects, such as extending reb A’s sweetness profile and controlling lingering sweetness, an effect similar to aspartame with acesulfame potassium. Which complementary sweetener you choose is dependent on the claims desired. Naturally based complementary

sweeteners would include erythritol, sucrose, fructose, glucose, fruit concentrates or monk-fruit concentrate.”

“Among the natural sweeteners, erythritol is particularly synergistic with the sweetness quality of rebiana,” suggests Fry. “Equally, ordinary sugars work well with rebiana in reduced-sugar formulations. As rebiana’s key advantage is its natural origin, there is little attraction in mixing it with synthetic sweeteners and these have largely been ignored as potential synergists.”

Adding high-purity stevia extracts to beverages is fairly straightforward given the sweeteners’ stability and lessons learned from long use of other high-intensity sweeteners.

For many other applications—including tabletop sweeteners, bakery, yogurt, ice cream and confectionery—stevia sweeteners share the same technological hurdle as other high-intensity sweeteners: Formulators have to find the correct bulking agents to replace caloric sugars’ mass and functionality.

“The choice of bulking agents depends on the claims you wish to make,” says Deis. “If sugar reduction is the goal—and not sugar-free—sucrose, fructose or glucose can be used, or a combination of polyols and sugars. Otherwise, erythritol and soluble fibers can be considered for natural and/or fiber claims.”

May suggests inulin “as an excellent bulking agent for stevia glycosides. It is also an excellent choice for ice-cream products, because it offers a smooth mouthfeel similar to milk and cream, but allows the reduction of these fats, thereby reducing the caloric content of the final product.”

The biggest problem with stevia-based sweeteners is that, while they are sweet, they don’t exactly mimic the flavor of sugar. “Replacement of sucrose with any other sweetener or replacement of other

### **Stevia Faces Consumer Perception Challenge**

*Consumer perception is the biggest challenge facing marketers of the natural sweetener stevia, according to an industry expert speaking at the F.O. Licht World Sugar conference this week in Germany.*

*As reported by [Reuters](#), Simon Bentley, of LMC International, said although industry leaders such as Coca-Cola, Pepsi and Cargill have started buying it, it is still largely unproven in the marketplace.*

*"The real test will be how consumers take to it," he said.*



sweeteners with another will always require flavor changes, because each sweetener has a unique sweetness profile and a unique flavor profile,” explains Deis. “Sweetness profiles can be changed with the addition of other sweeteners or sweetness potentiators that are complementary in profile—this is often required for all high-potency sweeteners. Past reports have shown that all high-potency sweeteners have some degree of bitterness associated with them at some level of use. For stevioside, this level is about 3% sugar equivalence. Reb A, although much improved vs. stevioside in sweetness quality, still has bitterness aftertastes that become more apparent above 6% sugar equivalence. Use of appropriate bulking sweeteners, complementary sweeteners and complementary flavors can help to extend the sweetness profile of reb A and improve the flavor profile.”