



Stevia

A Case Study on Use of Synthetic Biology Replacements

Farmers Affected: Tens of thousands.

Market Value: For stevia leaves and powders, etc.: \$347 million in 2014, growing rapidly to \$565.2 million by 2020¹; The market for stevia-sweetened goods (drinks, candies, etc.): \$8-11 billion (2015)²

Volume: Stevia consumption expected to reach 8,506.9 tonnes by the end of 2020³

Uses: Non-caloric sweetener

Syn Bio Companies: Evolva, Cargill, Stevia First, DSM

Hotspots: China (80%), Paraguay (3%), USA, Argentina, Colombia, Kenya,

Also Grown In: India, Vietnam, Brazil, South Korea, Taiwan

Cultural Importance: Traditional food, medicinal uses by indigenous Guarani people, highly prized in Paraguay; today seen as possible help in obesity epidemic

Biodiversity Considerations: Low land use, can be grown without agrochemicals, low CO₂ footprint

Quality issues: Syn Bio firms are not producing true stevia but only mimics of single “rebaudioside” compounds usually found in small quantities within the natural leaf. In some European states it is prohibited to represent these purified single compounds as “stevia.”

Products: Steviol glycosides (rebaudiosides) are widely used as sweeteners in dairy food products, bakery products, dietary supplements, confectionery, table top sweeteners, beverages, packaged food products, snacks.

Method: Synthetically engineered yeast

Commercialization: 2017

Feedstock: Corn syrup, sugar

Brands, Identifiers: Eversweet

Overview

Stevia (*Stevia rebaudiana*), a leafy plant characterized by its sweet taste, has its origins as a traditional food and medicinal ingredient of indigenous Guarani peoples in Paraguay and Brazil. Because of its rapidly-growing use as a zero-calorie natural sweetener, global demand for stevia is experiencing explosive growth. The revenue from stevia-sweetened goods was pegged at between \$8-11 billion US in 2015.⁴

Status: Syn bio stevia will be launched in 2017



R&D

Scale Up

Commercialization

Ingredient companies are now isolating the key sweetening compounds in stevia, steviol glycosides (sugars) known as rebaudiosides, and producing them individually for use in mainstream market brands. Some of these compounds are thought to have up to 350 times the sweetness of sugar and are being widely incorporated into leading soft drinks such as Coca Cola Life and Pepsi True as well as baked goods, candies, etc.

At least three commercial companies are working to commercialize steviol glycosides created through synthetic biology. Grain giant Cargill has teamed up with synthetic biology leader Evolva SA to engineer yeast to create rebaudiosides.



For more information on Synthetic Biology please visit the ETC Group website: www.etcgroup.org/synbio



Their syn bio sweetener, named Eversweet, is ready for market but has been delayed until 2017 while optimizing production and awaiting regulatory approvals. Cargill is already one of the world's largest players in stevia. Stevia First of California have also developed steviol glycoside ingredients produced from a similar fermentation process. A third company, the multibillion-dollar Dutch chemical producer DSM, is also scaling up its "fermented" syn bio stevia product.

What is Stevia?

Stevia is a natural sweetener for food and beverages derived from *Stevia rebaudiana*, a leafy plant originating in the border region of Paraguay and Brazil in South America. Characterized by its sweet taste, it is claimed to be a zero-calorie alternative to sugar. The use of stevia originates with indigenous Guarani peoples, who use whole stevia leaves medicinally as well as to sweeten Yerba mate and other foods. While whole stevia is still used, commercial use has focused on a range of single sugary compounds extracted from the stevia leaf, known as Steviol glycosides. These include Reb A (Rebaudioside A), Reb C, Reb F, Reb M, Reb D, Reb X and Stevioside. These compounds can have up to 350 times the sweetness of sugar. Some purified rebaudiosides (e.g. Reb A) have been approved for use in food products in major markets such as the US and Europe, even though the use of whole stevia leaf for food is restricted because regulators claim they have 'inadequate toxicological information' to determine safety. In response to growing concerns and regulatory action to counter the global obesity epidemic, the food and soft drink industry in particular is embracing use of these intensely sweet rebaudioside extracts as a means to cut down sugar in processed foods. Coca Cola for example uses stevia extracts in 45 different products, including its high-profile "Coke Life," sold in 15 different countries. According to business research compiler Future Market Insights, the global stevia ingredient market could reach \$565.2 million US by 2020, amounting to 15% of the global sweetener market, and revenue from stevia-sweetened goods was pegged at between \$8-11 billion US in 2015.⁵

According to the Global Stevia Institute, more than 5,000 food and drink products now contain steviol glycosides.⁶ In 2009 the World Health Organization estimated that steviol glycosides have the potential to replace 20-30% of all dietary sweeteners in the coming years.⁷

Stevia as a Natural Product

Stevia originated as a wild plant in Paraguay and the border region with Brazil; however, wild stevia is now virtually extinct.⁸ Today all stevia leaf comes from stevia farms. It is most widely cultivated in China, Paraguay, Argentina, Kenya and the United States, but is also being established in Colombia, India, Vietnam, South Korea, Taiwan and Brazil. Global cultivation in 2010 was estimated at 50,000 acres. Over 80% of stevia is grown in China and only 3% in its place of origin, Paraguay.

Stevia growing was introduced to Kenya by Malaysian Company PureCircle Inc. and acreage has rapidly grown since. PureCircle buys all 10,000 tonnes of Kenyan stevia leaf from 5-6,000 Kenyan farmers based in eleven counties and hopes to scale up Kenyan growing of this crop to 10,000 farmers. When ETC Group spoke with Kenyan stevia farmers in Kericho county, we learned they typically devoted a quarter to half an acre of their small farm to stevia. However, the comparatively high prices for growing stevia were leading them to uproot their tea crops to plant stevia, and there was a lot of excitement and pride in the new cash crop. The leaves can be harvested every 2-3 months (by hand) and bushes last for five years before quality drops.⁹

Most of the world's stevia leaf is chemically processed into steviol glycosides by a handful of companies, principally PureCircle and Cargill. The most widely used glycoside is Reb A, which also has the highest concentration in stevia leaves. However, Reb A suffers from a slightly bitter metallic aftertaste; so its use in soft drinks and other applications needs to be supplemented by sugar. Subsequently stevia companies have been trying to commercialize other glycosides found in much smaller quantities in natural stevia, such as Reb X, Reb D and Reb M.

Because of the smaller quantities per leaf, larger harvests are required to extract commercially useful amounts. US and European regulators have approved several specific steviol glycosides for food consumption, including Reb A, Reb C, Reb D, Reb F, Reb M and Reb X. Indigenous advocates and some natural health practitioners point out that it is misleading to call these purified rebaudioside ingredients "stevia," "natural," or to use images of the leaf. In some countries (eg. Germany, Switzerland and Austria) national guidelines prohibit misrepresenting chemically purified rebaudiosides in these ways.¹⁰

Biodiversity and Cultural Considerations

Much of the marketing around commercial stevia stresses its origin from indigenous communities. Stevia was originally used as a sweetener and medicine by the Kaiowa Guarani in Brazil and the Pai Tavytera Guarani communities in Paraguay, who refer to it as Ka'a He'ê (meaning "sweet herb"). Paraguay in particular regards stevia as a national treasure. The Pay Tavytera have a small population of 15,000 who now have access to only a small part of their traditional territory. Despite being hunters, fishers and gatherers, they are increasingly dependent on small scale agriculture and paid work on cattle ranches. The Brazilian Kaiowa Guarani have dwindled to 46,000 people who have also lost most of their territory and are now largely living precarious lives on small reserves surrounded by sugarcane plantations and cattle farms, where many work in slave-like condition.¹¹ Many indigenous advocates and others have pointed to the current commercial boom in steviol glycosides as a classic case of biopiracy, where the original stewards of stevia are granted absolutely no benefits from the ever larger corporate profits flowing from this plant in the global marketplace.

In biodiversity terms, stevia appears to be an ecologically benign crop. Stevia farmers that ETC Group interviewed in Kenya stressed that the plant does not require agrochemicals. The Kenyan farmers apply organic manure and weed by hand.¹² The Global Stevia Institute claims that stevia is a land-sparing crop, since high production can be attained on small bits of land.

Significantly, it may also be a much less carbon intensive crop than other sweeteners like sugar cane, and including the sugary feedstocks like corn syrup used for producing syn bio steviol glycosides. In a 2013 study, the carbon footprint of natural stevia was shown to be 79% lower than high fructose corn syrup (HFCS), 55% lower than beet sugar, and 29% lower than cane sugar, based on industry production standards.¹³ A similar study in 2012 claimed that "high purity stevia sweeteners have a carbon footprint that is as much as 82% lower and a water footprint that is as much as 97% lower than other publicly available sweetener benchmarks".¹⁴

Synthetic Biology Production

There has been intense interest and competition to commercialize the synthetic biology production of steviol glycosides, driven by two key factors. Firstly, synthesizing some of the rarer glycosides inside engineered microbes (ie. Reb X, Reb M and Reb D) holds out the possibility of being able to cheaply mass produce a steviol glycoside that does not have the bitter aftertaste of the more abundant Reb A. Even more exciting for the industry is the prospect that in many jurisdictions, the products of synthetic biology can be legally described and labelled as "natural" (because fermentation is legally considered a natural process). This means that such syn bio steviol glycosides could be very quietly incorporated into profitable natural products markets.

Two of the three companies working on syn bio stevia are large firms racing for commercialization. Cargill and Evolva's joint venture to commercialize Reb M and Reb D has been consistently ahead of schedule. They established a pilot production plant in Blair, Nebraska and in October 2015 they unveiled their commercial sweetener, dubbed "Eversweet," at a large ingredients conference in Las Vegas. They had expected it to enter the market in 2016. However, Evolva now says that Eversweet's entry to the US market will be later as they are attempting to bring costs down and are still waiting for the substance to receive USDA approval as GRAS ("Generally Recognized As Safe")¹⁵

Cargill's existing stevia line ("Truvia") and its relationship with Coca Cola, puts both corporate giants in a position to realize high profits, particularly if Coca Cola chooses to substitute real stevia for Eversweet in their "Coke Life" product. Meanwhile, DSM, a large Dutch chemical and ingredients producer, had announced in 2014 that they were seeking USDA GRAS approval for another syn bio stevia and intended to launch their syn bio stevia product by the end of 2015.¹⁶ DSM's syn bio yeast produces Reb A, the bitter one. It is expected that both DSM and Cargill/Evolva will seek to market their syn bio steviol glycosides as "natural" ingredients, even though they come from an almost unimaginably extreme genetic engineering process. "We are getting a yeast to produce stevia much as a yeast might produce alcohol, something that is impossible in the natural world," says Greg Kesels, Regional President of Food Ingredients for DSM. Without missing a beat, he concludes "...it is exactly the same product as you might find in nature." Other companies in the US are also getting onboard this train, like Stevia First of California.¹⁷

Implications for the Future

Syn bio steviol glycosides are poised over the next few years to be one of the largest volume and most commercially important synthesized ingredients to enter a vast amount of food and beverages. Whether DSM or Evolva/Cargill commercialize first, the switch in human consumption of a syn bio-derived sweetener will probably not be advertised. Consumers will continue to be told that they are being offered a "natural" product. Already some companies producing leaf stevia have been speaking out against this coming deception.

In 2014, Pure Circle Stevia said that their polling data showing that consumers expect natural stevia to come from a plant¹⁸; and in 2015, a number of stevia trade associations openly attacked the new syn bio "fermentation" stevias as likely to damage the industry's reputation:

Euromonitor analyst Simone Baroke warns: "Stevia's already wobbly status as the only "natural" low-calorie sweetener is about to be thrown into even greater jeopardy... The mere fact that a product is based on an innocuous raw material is not sufficient to pull the 'natural' wool over consumers' eyes." The European Stevia Association (EUSTAS) concurred: "Of course this will damage the natural reputation of stevia even if (in Europe) stevia extracts are not allowed to be labelled as "natural" but from "natural origin", board member Monica Lorenzo also told *FoodNavigator*, adding, "The expectation of consumers is to get a natural product, and this is no longer the case when produced through fermentation. Furthermore, this is not a fermentation process that could be considered as natural (like for cheese, wine, beer, yoghurts...) but a fermentation process that uses genetically modified yeast, so a type of production that doesn't exist in nature."¹⁹

At the same time, cultivation of true leaf stevia is ramping up, providing much-needed income for small farmers, especially in Kenya. Farmers, in many cases, who also grow a variety of food crops, are effective stewards of local biodiversity. However, if companies like Evolva can scale up production of synthetic yeast (and steviol glycosides), the benefits of the growing market for stevia may go to the shareholders of Cargill and Evolva instead of small farmers. Instead of sustainable cultivation, production based on synthetic organisms could drive demand for sugar, a crop associated with deforestation and human rights abuses, as well as high CO₂ emissions.

Endnotes

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