



Vanilla

A Case Study on Use of Synthetic Biology Replacements

Farmers Affected: 200,000

Market Value: \$150 million US (beans)
\$650 million US (beans and synthetic)

Uses: Flavour, fragrance

Syn Bio companies: Evolva, International Flavors and Fragrances (IFF)

Hotspots: Madagascar, Comoros, Réunion, Uganda, Mexico, Tahiti

Also Grown In: Indonesia, China, Democratic Republic of Congo, Tanzania, French Polynesia, Malawi, Tonga, Turkey and India

Cultural Importance: Used in Mexico since at least the 1400s as flavouring, tribute, currency: the Fruit of the Gods. The most popular flavouring in the world today, used in countless foods, beverages, cosmetics, household products.

Biodiversity Considerations: Agroforestry cultivation method protects forests and biodiversity; prevents deforestation because it is generally cropped in the forests.

Quality Concerns: Only a few of the hundreds of chemical components in true vanilla are being synthesized in the synthetic biology version – primarily the compound vanillin. Despite being synthetically produced by bioengineered yeast Evolva and IFF intend to misrepresent their product to consumers as a ‘natural flavour’.

Patents: WO 2013022881

Products: “Always Vanilla”

Method: Synthetically engineered yeast

Commercialization: Already on market

Overview

Natural vanilla is derived from the cured seed pod of the vanilla orchid, which grows as a vine in tropical climates. Vanilla production is labour intensive, requiring cultivators to hand-pollinate vines dispersed in forested areas. The pods take about five months to mature, after which they are collected by hand and cured. An estimated 200,000 people are involved in the global annual production of cured vanilla beans. Madagascar, Comoros and Réunion historically account for around three quarters of the world’s vanilla bean production. At the consumer end, natural vanilla sells for thousands of dollars per kilogram, while synthetic “vanillin” sells for about ten times less.

Status: Syn bio vanillin is already on the market



R&D

Scale Up

Commercialization

Evolva, a Switzerland-based synthetic biology company, has partnered with US industry giant International Flavors & Fragrances (IFF) to engineer metabolic pathways in microbes to produce key flavor compounds found in vanilla. Evolva and IFF commercialized a bio-synthesized vanillin flavor in 2014 which is now sold as part of IFF’s “Always Vanilla” line.¹



For more information on Synthetic Biology please visit the ETC Group website:

www.etcgroup.org/synbio



What is Vanilla?

Vanilla (Spanish for “little pod”) is both a plant and the flavouring derived from it. Its origins are in Mexico, and because of a specific local pollinator, could not be grown elsewhere until the 19th century. A slave, Edmond Albius living on the island of Reunion in the Indian Ocean, discovered how to easily hand-pollinate it. Since then, the production of the species *Vanilla planifolia* is the most common.² This is known as Bourbon or Madagascar Vanilla and is produced still in the area of Madagascar and Reunion, as well as in Indonesia, China, Mexico, Uganda and other tropical countries.

Vanilla is the second-most expensive plant-derived flavouring in the world, after saffron, because growing the vanilla seed pods and hand-pollinating them is so labor-intensive. Despite the expense, vanilla is highly valued for its flavor, widely used in commercial and domestic baking, perfume manufacture and aromatherapy.³

Vanilla as a Natural Product

Vanilla essence occurs in two forms. Real seedpod extract from the tropical orchid is an extremely complicated mixture of several hundred different compounds, including vanillin, acetaldehyde, acetic acid, furfural, hexanoic acid, 4-hydroxybenzaldehyde, eugenol, methyl cinnamate, and isobutyric acid. Of all these, the vanillin compound (4-hydroxy-3-methoxybenzaldehyde), a major contributor to the flavour and aroma of real vanilla, was first isolated from vanilla pods as early as 1858. Vanillin is now easily synthesized from various raw materials, but the majority of food-grade (>99% pure) vanillin is made from guaiacol in a solution of ethanol; it is usually synthesized from the wood-pulp residue of paper-making. Other sources, including the castoreum from the scent sac of beavers, may also be components in non-orchid-derived vanillin.⁴

However, so many other compounds contribute to the complex vanilla flavour that the single component vanillin can only approximate. For this reason, real vanilla has never been fully replaced on the market and its “standard of identity” is closely regulated.

An estimated 200,000 people are involved in the annual production of cured vanilla beans worldwide. Industry analysts predict that the market for vanilla beans exports worldwide will reach an estimated

\$150 million US in 2013, with African producers accounting for approximately 64% of the total export market.⁵

Production of natural vanilla from vanilla beans uses a lot of workers: 1 kg of vanilla requires approximately 500 kg of vanilla pods and the hand-pollination of approximately 40,000 flowers.

Madagascar and other island nations in the Southwest Indian Ocean (Comoros, Réunion) historically account for around three

quarters of the world’s vanilla bean production—and continue to dominate the market today. Vanilla bean production and processing is a vital cash crop in agroforestry systems where there are few alternative income sources. In Madagascar, an estimated 80,000 families cultivate vanilla orchids on approximately 30,000 hectares. In Comoros, about 5-10,000 families depend on vanilla bean production. Approximately 10,000 farm families cultivate vanilla orchids in Mexico, the geographic origin of vanilla. About 8,000 families in Central Africa (Uganda, Democratic Republic of Congo, Tanzania) also depend on vanilla bean production. In recent years Indonesia and China have become major vanilla bean producers; other producers include French Polynesia, Malawi, Tonga, Turkey and India.⁶ In recent years, disease, storms, but especially synthetics (vanillin and soon, syn bio) have been taking more of the market share. The industry has been shaken to the extent that some worry that true vanilla could start disappearing from cultivation.⁷

“I have no other means of survival. I just have to sell vanilla... [without it] we can no longer buy food, pay bills, medical bills, house rents, school fees.” When told even the alternative crop, cocoa, might become synthesized, he said, “...then we prepare to die.”

Jean Michel, vanilla farmer,
Madagascar⁷

So many poor livelihoods are affected worldwide that the swings in prices have alarmed many researchers. Programs from Fair Trade labeling to corporate and government alliances are trying to establish model farms where both inputs and prices can be stabilized for vanilla workers.⁸

Biodiversity and Cultural Considerations

By the 15th century, the Totonacs, who peopled the area now known as Veracruz on the east coast of Mexico, had passed on their use of the vanilla pod to the Aztecs, as both a valued tribute and a form of currency. The Totonacs called it the Fruit of the Gods, the Spanish valued it as an aphrodisiac. Because only a local bee had evolved to pollinate it, it wasn't until the 19th century that a 12 year-old slave boy far away on the island of Reunion learned how to hand-pollinate it. It then became a major crop in that area.⁹

The vanilla cropping system, especially in Madagascar, is regarded as a vital part of the maintenance and sustainability of agroforestry areas, which are mainly organic. The vanilla orchid vines rely on tropical forest shade and support, and require a great deal of work to cultivate, harvest and process. Because the vanilla orchid grows as a vine, climbing up an existing tree (also called a tutor), pole, or other support, it can be grown in a forest and so is closely linked to forest protection and conservation.¹⁰

In a 2014 interview with ETC Group, Madagascan vanilla farmer Tsara Samson from Sambava region explained that: "...The forest is protected by the people to help preserve their vanilla beans, because it needs to grow in the shadow the forest provides. If they can no longer grow vanilla because it has lost its value, the forest in most communities will be cleared." He went on to say that "Vanilla acts as an Environmental Protection for the forest, because [currently], they take care of the forest and the forest takes care of their vanilla, it's a win-win situation. They periodically plant trees to replenish the old ones, all because of the vanilla beans."¹¹

Synthetic Biology Production

Evolva, a Switzerland-based synthetic biology company, has partnered with US industry giant International Flavors & Fragrances (IFF) to engineer metabolic pathways in microbes to produce key flavor compounds found in vanilla. In 2014 Evolva and IFF commercialized a biosynthesized vanillin flavor which is now sold as part of IFF's 'Always Vanilla' line.¹² Evolva has biosynthesized several molecules involved in the complex flavor profile of natural vanilla – primarily the substance vanillin. ETC Group understands that this new ingredient is already being incorporated into flavor mixes sold by IFF. Evolva maintains that simply because the product is fermented, this flavor (and any mixes that contain it), can be legally sold as a "natural flavour."

According to investment analysts, the company's key advantage is that its syn bio-based fermentation route allows Evolva to sell this so-called "natural" vanillin at a price that is lower than other natural vanilla flavours.¹³ Evolva acknowledges that the flavor of the company's biosynthesized vanillin is not equivalent to the flavoring derived from the cured vanilla bean; but claims that the taste profile of vanillin produced by engineered yeast is more complex and closer to the natural vanilla flavor than artificial vanillin. Evolva has engaged in glossy, consumer-focused efforts, including a cartoon video, to overcome consumer resistance to syn bio vanillin. They feel they can market this new synthetic as being "more sustainable and higher quality."¹⁴

Implications and the Future

Despite high-profile corporate pledges to source raw materials ethically and sustainably, the world's largest brokers of flavor and fragrance ingredients (e.g., Givaudan, Firmenich and IFF) are partnering with synthetic biology companies for the biosynthesis of high-value flavor/fragrance molecules like vanilla. This move could dramatically reduce botanical imports and impoverish hundreds of thousands of small-scale farmers.

From the consumer's point of view, if government regulators continue to permit Evolva and IFF to market new, biosynthesized products such as the Always Vanilla product as “natural” consumers will not know if their flavor/fragrances are sourced from small farmers in the tropics, or from human-created microbes in giant fermentation tanks in industrial factories.

For the ingredients giants, the synthetic biology platform offers the potential to secure uninterrupted supplies of these high-value, flavor/fragrance/ pharmaceutical plant compounds in industrial-scale fermentation tanks, instead of sourcing plant materials from equatorial farmers. Synthetic microbial cell factories are fully in the control of large corporations and less constrained by geography, extreme weather, crop failures and price volatility. They will remove the farm families whose livelihoods depend on cultivation of high-value botanical exports from the trade equation, and possibly make the forests less viable for preservation as well.

The commercial success of biosynthesized vanillin ultimately depends not just on competitive price or flavor, but on misleading the consumer with “natural” claims. Recent precedent suggests that biosynthesized vanillin produced via fermentation may indeed get away with carrying the “natural” label: Chemical giant Solvay (Belgium) already makes a vanillin ingredient via the fermentation of ferulic acid derived from rice bran. Government regulators have permitted Solvay’s vanillin to be labeled “Natural flavoring/Flavor/Vanilla flavor” (EU) or “Vanillin derived by a natural process” (US) and this appears to be the precedent Evolva and IFF are following, that misleads consumers.¹⁵

While Evolva insists that its biosynthesized vanillin is not designed to compete with farmer-grown vanilla beans, if the company succeeds in selling its vanillin flavor as “natural” and offers it at a fraction of the cost of botanically-derived vanilla, even cheaper than existing synthetic vanillins, then it may capture a significant portion of the already stressed natural vanilla bean flavor market, and harm tropical farmers.

Endnotes

- 1 Edison Investment Research note on Evolva – Feb 2015
Available at www.edisoninvestmentresearch.com/?ACT=18&ID=13730
- 2 *V. tahitensis* is grown in the South Pacific; and *V. pompona* is used in the West Indies and Central and South America. See Besse, Pascale; Silva, Denis Da; Bory, Séverine; Grisoni, Michel; Le Bellec, Fabrice; Duval, Marie-France (2004). “RAPD genetic diversity in cultivated vanilla: *Vanilla planifolia*, and relationships with *V. Tahitensis* and *V. Pompona*.” *Plant Science* 167 (2): 379–85. doi:10.1016/j.plantsci.2004.04.007
- 3 Le Cordon Bleu (2009). *Le Cordon Bleu Cuisine Foundations*. Cengage learning. p. 213 ISBN 978-1-4354-8137-4. ;Parthasarathy, V. A.; Chempakam, Bhageerathy; Zachariah, T. John (2008). *Chemistry of Spices*. CABI. p. 2. ISBN 978-1-84593-405-7; Rosengarten, Frederic (1973). *The Book of Spices*. Pyramid Books. ISBN 978-0-515-03220-8. See also <https://en.wikipedia.org/wiki/Vanilla>
- 4 “About Vanilla – Vanilla imitations,” *Cook Flavoring Company*, 2011; see also Burdock GA (2007), “Safety assessment of castoreum extract as a food ingredient,” *Int. J. Toxicol.* 26 (1): 51–5. doi:10.1080/10915810601120145. PMID 17365147.
- 5 Personal communication 2011 between ETC Group and Michel Grisoni, CIRAD (Centre de cooperation internationale en recherche agronomique pour le developpement), based in Reunion. All estimates for vanilla production and agronomic factices provided by M,Grisoni. For other estimates, see Daphne Havkin-Frenkel, Faith C. Belanger, eds., *Handbook of Vanilla Science and Technology* p. 115; <https://books.google.ca/books?id=ZCraZokdYrkC&pg=PA112&lpg=PA112&dq=vanilla+workers+worldwide&source=bl&ots=9vFF3oOPqi&sig=0mciyDfCIxHFjj1KB7snjRN5co8&hl=en&sa=X&ved=0ahUKEwiijd7gkpbMAhUMdz4KHV9MCUkQ6AEIOTAF#v=onepage&q=vanilla%20workers%20worldwide&f=false>
- 6 *Ibid.*
- 7 Interview with Jean Michel, President of the S.V.M Cooperatives - NOSIARINA Community. Sava Region of Madagascar - 19th February 2015. Interview conducted by Marian Bassey of ETC Group.
- 8 Braw, E. “Future of Rural Vanilla Farming at Risk as Market for Synthetic Alternative Grows,” *The Guardian*, Mar 3, 2014; www.theguardian.com/sustainable-business/vanilla-farming-rural-future-risk-synthetic
- 9 <https://en.wikipedia.org/wiki/Vanilla>; see also Patricia Rain, *Vanilla: The Cultural History of the World's Favorite Flavor and Fragrance*, www.amazon.com/Vanilla-Cultural-History-Favorite-Fragrance/dp/1585423637
- 10 Interview with Michel Grisoni, Centre de coopération internationale en recherche agronomique pour le développement (CIRAD), Reunion, 2011. See also Braw, E., *loc. cit.*
- 11 Interview with Tsara Samson of Andranomifotitra Community in Sambava Region – Feb 2015. Interview conducted by Marian Bassey of ETC Group
- 12 Edison Investments Note on Evolva, 15 Jan 2016 - www.evolva.com/wp-content/uploads/2016/01/Edison-15Jan2016.pdf
- 13 See also The Guardian Mar 3 above; Melody Bomgardner, “The Sweet Smell of Microbes,” *Chemical & Engineering News*, July 16, 2012, p. 26.
- 14 Personal communication with Evolva CEO, Neil Goldsmith, October 5, 2011. Email communication from Neil Goldsmith on October 10, 2013. For cartoon video see: www.youtube.com/watch?v=y96w21HkaHQ
- 15 www.rhodia.com/en/binaries/Rhovanil_Natural_Highlight_2013.pdf; IFF. 2013, Moving Forward, our sustainability report 2012. <http://www.iff.com>; see also Givaudan–2012 Annual Report; <http://www.givaudan.com> and Firmenich News Release. “Firmenich Becomes the First Flavor House to Offer Rainforest Alliance Certified™ Vanilla,” March 27, 2013. www.firmenich.com