

Synthetic Biology Vanillin: not natural, not sustainable, not likely to be labeled, and coming to an ice-cream cone near you

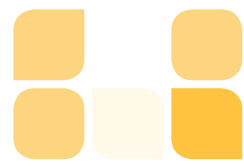
A new ingredient is about to enter the global food supply in many of our favorite foods from ice cream to birthday cake. And like many of the products of genetic engineering, it won't be carrying a label-- instead it is being marketed as "natural".

This ingredient, synthetic biology vanillin, has been created using synthetic biology (aka extreme genetic engineering) and Evolva®, the company producing this ingredient, together with the International Flavors and Fragrances (IFF), plans to market its product as a food additive starting in 2014. Synthetic biology is an extreme form of genetic engineering, in which scientists write entirely new genetic code on a computer, "print" it out and then insert it into organisms to serve specific functions.

Recent polls found that as the public learns more about synthetic biology, people are increasingly concerned about its risks. One-third of respondents favored a complete ban on synthetic biology products until the risks and implications are better researched¹. Despite marketing claims, this "vanillin" produced through synthetic biology is not environmentally sustainable or "natural", and threatens the livelihoods of small, sustainable, natural vanilla farmers in rainforests around the world. Due to inadequate regulatory oversight and assessment of risks to human and environmental health, government scientists still know little about the safety of this product.

Vanilla is one of the most widely used flavors in our food, and therefore this new application is in the spotlight of the public controversy. Synthetic biology vanillin would be one of the biggest, high profile uses of this new experimental genetic technology in our food system. It will set a precedent allowing for the use of this technology to create other synthetic biology food derivatives such as orange and grapefruit flavoring, coconut oils, and saffron. Already, a synthetic biology produced animal feed ingredient has been approved by the FDA based solely on the company's claim that the product is safe. Self-auditing is not legal for financial accounting, nor should it be for this new technology. We need a strict and thorough regulatory process and framework for this emerging biotechnology before these products pervade our food system.

Synthetic biology is a form of extreme genetic engineering. Synthetic biology is the "design and construction of new synthetic biological parts, devices, and systems that do not exist in nature and the redesign of existing biological organisms"². Instead of taking whole and existing genes from one natural species and inserting them into another, typical in "traditional" genetic engineering, synthetic biology creates entirely new DNA sequences by using computers to compile mixtures of "building blocks" from known or invented genes with the goal of creating specific products to perform unnatural tasks, such as yeast producing vanillin^{3,4}.



However, as with genetic engineering, sometimes the combination of unique parts results in new, unpredictable traits that none of the individual components would exhibit on their own. New discoveries about genetics and biology clarify that our incomplete understanding of when and how gene traits are expressed indicates that it will be very hard to know the impact of any synthesized DNA on the health of an organism or ecosystem to which it is introduced^{6,7,8}.

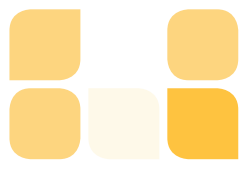
Vanillin is the primary flavor component of vanilla, the world's most popular natural flavor. The only way to obtain it naturally is from the cured seed pod of the vanilla orchid⁹. Natural vanilla is produced and harvested by small farmers in rainforests in Madagascar, Mexico and across Southeast Asia.

Synthetic biology vanillin is distinct from the artificial vanillin already on the market, although both are engineered in labs. Artificial vanillin is a mix of chemical components. The new synthetic biology vanillin is synthesized by a genetically engineered organism. While synthetic biologists claim that the yeast's fermentation process is natural¹⁰, it requires computer coded yeast that only exists inside of a lab.

Synthetic biology vanillin is made with a new synthetic genetic code inserted into yeast. Using a computer, scientists edit the DNA in yeast and insert the computer generated DNA, and then through a fermentation process, force the yeast to biosynthesize vanillin¹¹. Even though this vanillin is engineered and created by a pathway that does not exist in nature, the synthetic vanillin marketers, Evola® and its partner, International Flavours and Fragrances, are trying to distance synthetic biology from genetic engineering stigma and market it as "natural".

Natural Vanilla depends upon intact tropical ecosystems, and its harvest is very labor intensive. Pure vanilla comes from the Vanilla orchid: *Vanilla planifolia*. Each flower is pollinated, harvested, sorted and cured by hand. One kilogram of vanilla extracts requires about 500 kg of these vanilla beans¹². The knowledge of vanilla farming is intertwined with its cultural importance and its tradition has been passed between families for hundreds of years. Without the natural vanilla market adding economic value to the rainforest in these regions, these last standing rainforests will not be protected from deforestation and sugar cane used to feed the yeast will replace the forests.

Synthetic biology vanillin will severely impact the natural vanilla market and could harm sustainable farmers and poor communities across the world. The natural vanilla market depends on consumer demand. Without labeling requirements, consumers will not know if the "natural" product is made with real vanilla beans or synthetic biology vanillin. This could devastate the international natural vanilla market. Natural vanilla is a high value natural product, and sells for \$1,200-\$4,000 per kilogram. Internationally, the natural vanilla market is approximately \$240 million per year. This is a significant part of the economy for the vanilla growing regions, which are primarily in developing countries such as Madagascar, which produces three quarters of the world's



vanilla, Indonesia, Mexico (where the vanilla orchid originated), and increasingly East Africa and China¹³. The decreased demand could devastate livelihoods of approximately 200,000 people who are involved with the production of cured vanilla beans per year, as well as the intact natural and diverse ecosystems where vanilla grows and therefore protects^{14,15}.

Production of synthetic biology vanillin is not environmentally sustainable at the industrial scale. It is promoted as “green” because it uses a fermentation process. However, the yeast is genetically engineered with computer generated DNA. The immense amount of sugar required for efficient vanillin synthesis encourages monocultures of fast-growing sugars instead of the rich biodiversity of the tropical ecosystems which are host to the vanilla orchid¹⁷. Sugar plantations contribute to rainforest deforestation and are known for slave labor working conditions. The synthetic biology vanillin process may also lead to the removal of biomass needed for healthy agricultural soil . Lastly, synthetic organisms threaten biological diversity if they escape into the environment – either intentionally or unintentionally from a lab. Once “living self-replicating organisms” are released, there is no way to remove them. They could become a new class of invasive species or pollutant and disrupt ecosystems¹⁷.

It is unclear if synthetic biology vanillin is safe to eat, or what impacts if the synthetic organisms may have upon were interact with natural organisms or ecosystems. We do not have adequate regulatory agencies or sufficient independent data to determine this. Without precautionary testing and regulations that are specific to synthetic biology and which recognize it is as a unique and complex technology, we may not find emergent health threats until it is too late¹⁸.

There is a lack of Federal regulations for synthetic biology. Similar to regulatory challenges with genetically engineered products, the FDA has not developed risk assessment protocols to assess whether the byproducts of synthetic biology may pose ecological risks in the likely event that these unique new synthetic organisms escape into the environment¹⁹. Instead of approving vanilla made from this new experimental genetic technology as “Generally Regarded As Safe”, without specific agency tests, regulatory agencies should test each new product and assess whether it is safe for use in foods. Currently, weak regulations around genetic engineering and synthetic biology could allow this engineered SynBio vanilla flavoring to be labeled as “natural” under US and EU labeling regulations²⁰.

Synthetic biology vanillin must be kept out of our food system. The FDA should develop a strong regulatory framework for this new biotechnology, and international regulations to manage the novel risks to human health and the environment. Until then, synthetic biology vanillin should not be allowed on the market and into our ice cream, and many other food products containing vanilla flavoring.

Friends of the Earth, the Center for Food Safety, and the Etc group are working federally and internationally to advocate for governmental regulatory frameworks for synthetic biology that ensures precautionary analysis of potential risks before these computerized unique organisms are introduced into our food and environment. If the FDA or any other



nation's food safety agency decides to approve the synthetic biology vanillin, companies should commit to not using it in their products. Governments should require mandatory labeling to allow consumers to make informed purchasing decisions. Vanillin produced through synthetic chemistry must be labeled "artificial", as should vanillin produced through synthetic biology.

How do I get Involved?

The Switzerland-based synthetic biology company, Evolva®, plans to release its commercial product of synthetic biology vanillin in 2014 through a partnership with International Flavors and Fragrances (IFF). Companies should commit to using authentic and verifiable natural vanilla, ecological and social responsibility, and pledge to not purchase synthetic biology vanillin from Evolva® or IFF.

Visit our website at www.foe.org/projects/food-and-technology/synthetic-biology/no-syn-bio-vanilla to learn more about getting involved at all levels!

-
- ¹New Poll Finds Synthetic Biology Remains a Mystery. Woodrow Wilson Center and Hart Research. March 2013: http://www.synbioproject.org/news/project/synthetic_biology_remains_mystery/
- ²International Civil Society Working Group on Synthetic Biology, ETC Group, Econexus, Friends of the Earth USA, International Center for Technology Assessment, & Sustainability Council of New Zealand. (2011).
- ³BCC Research. Summary of Synthetic Biology: Emerging Global Markets. June 2009: <http://www.bccresearch.com/report/BIO066A.html>
- ⁴Keasling, J. D. 2010. Manufacturing molecules through metabolic engineering. *Science* 330:1355-1358.
- ⁵Newman, S. 2002. Developmental mechanisms: putting genes in their place. *J. Biosci.* 27, 97-104.
- ⁶European Commission. 2009. Ethics of Synthetic Biology, European Group on Ethics in Science and the New Technologies to the European Commission, Opinion No. 25, Brussels, 17 November 2009.
- ⁷Lloyd's Emerging Risk Team Report. 2009. Synthetic biology influencing development. www.lloyds.com/emergingrisks
- ⁸International Civil Society Working Group on Synthetic Biology, ETC Group, Econexus, Friends of the Earth USA, International Center for Technology Assessment, & Sustainability Council of New Zealand. (2011).
- ⁹Vanilla. (2013). Retrieved June 19, 2013, from Evolva website: <http://www.evolva.com/products/vanilla>
- ¹⁰Erickson, B., R. Singh and P. Winters. 2011. Synthetic biology: regulating industry uses of new biotechnologies, *Science*, Vol. 333, September 2, 2011
- ¹¹Griffith F. The significance of pneumococcal types. *J. Hygiene.* (1928);27:113-159. Hansen, EH, B. L. Møller, G. R. Kock, C. M. Büchner, C. Kristensen, O. R. Jensen, F. T. Okkels, C.E. Olsen, M. S. Motawia, and J. Hansen. 2009. De novo biosynthesis of Vanillin in Fission yeast (*Schizosaccharomyces pombe*) and Baker's yeast (*Saccharomyces cerevisiae*). *Applied and Environmental Microbiology* 75: 2765-2774.
- ¹²ETC Group. (2012, July). Synthetic biology: Livelihoods and biodiversity. Retrieved June 19, 2013, from ETC Group website: http://www.etcgroup.org/sites/www.etcgroup.org/files/CBD_Vanilla_case_study_TA.pdf
- ¹³Koekoek, F. J. (2005, February). The natural vanilla markets; With special attention for the organic segment. Bennekom, The Netherlands: Export Promotion of Organic Products from Africa.
- ¹⁴International Civil Society Working Group on Synthetic Biology, ETC Group, Econexus, Friends of the Earth USA, International Center for Technology Assessment, & Sustainability Council of New Zealand. (2011).
- ¹⁵ETC Group. (2012, July).
- ¹⁶Blanco-Canquia, Humberto and Lai, R. 2009. Corn Stover Removal for Expanded Uses Reduces Soil Fertility and Structural Stability, *Soil Sci Soc Am J.* 73: 418-426
- ¹⁷Snow, A. 2010.
- ¹⁸International Civil Society Working Group on Synthetic Biology, ETC Group, Econexus, Friends of the Earth USA, International Center for Technology Assessment, & Sustainability Council of New Zealand. (2011).
- ¹⁹Snow, A. 2010. "Risks of Environmental Releases of Synthetic GEOs." Invited Presentation for the Presidential Commission for the Study of Bioethical Issues, July 8, 2010. Professor Allison A. Snow, Ph.D., Department of Evolution, Ecology, and Organismal Biology, The Ohio State University, Presentation available at www.bioethics.gov
- ²⁰Vanilla. (2013). Retrieved June 19, 2013, from Evolva website: <http://www.evolva.com/products/vanilla>