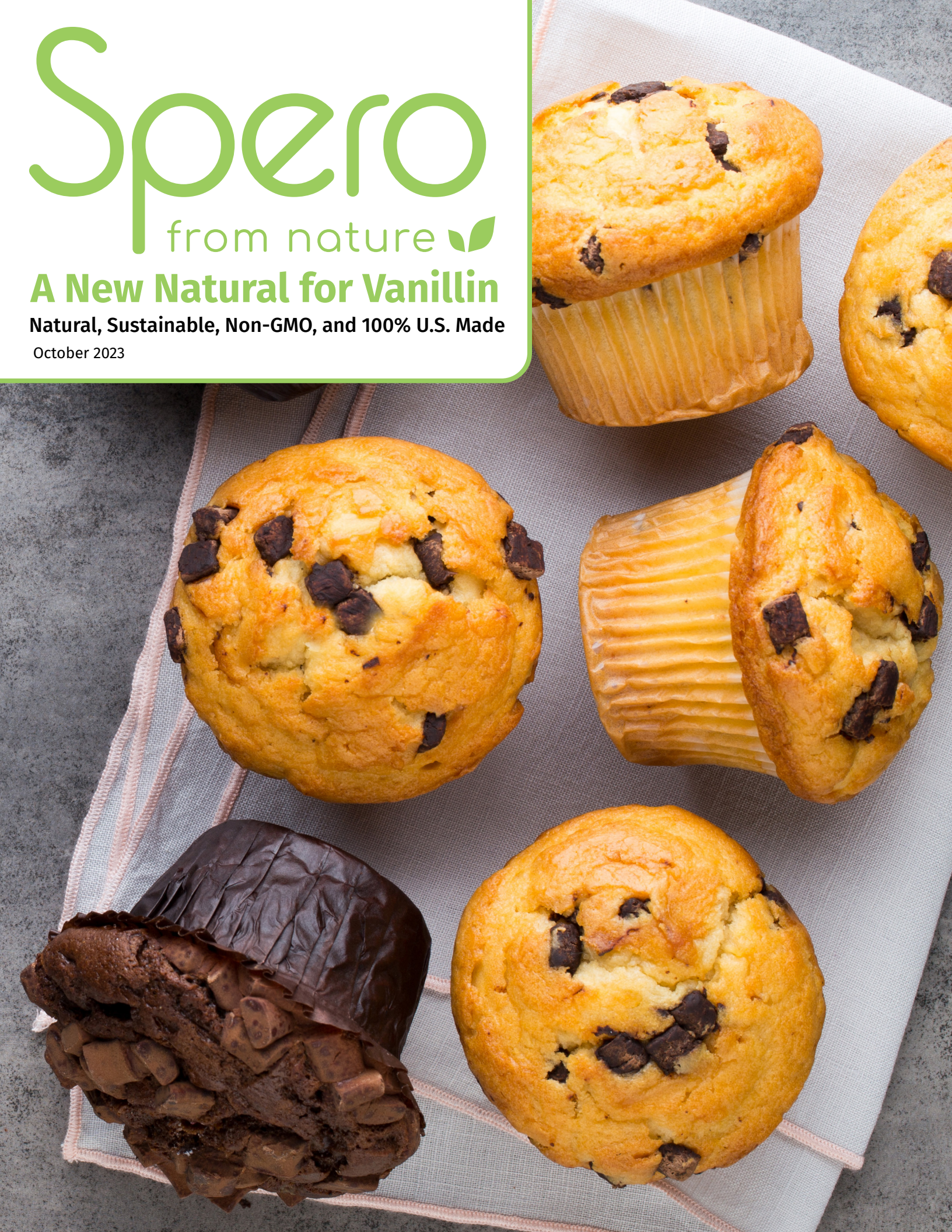
Spero

from nature

A New Natural for Vanillin

Natural, Sustainable, Non-GMO, and 100% U.S. Made

October 2023

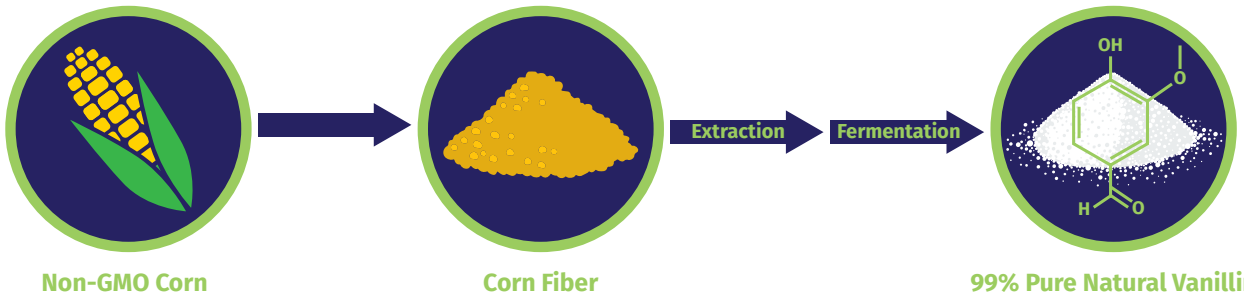


Consumer appreciation for vanilla is global. Each year, vanilla vies with chocolate for the world's most favored flavor. On top of that, most chocolate formulations rely on at least some vanilla to help enhance and round out the flavor of chocolate and help mask its natural bitter notes. Together, these factors make the demand for vanillin – the flavor molecule responsible for vanilla's beloved flavor – extremely high. Much higher, in fact, than can be sourced from the vanillin found in harvested vanilla beans.

Vanilla beans (Vanilla planifolia) are actually the fruiting pod of an orchid native to the New World (although a different species native to the ancient Middle East was recently verified). A mostly tropical plant, Spanish and French explorers brought vanilla to their island holdings across the globe. Vanilla is now grown on several continents, with the majority coming from Madagascar and Indonesia. However, only a little more than a dozen countries in total produce the crop, which is notoriously difficult to grow, propagate, and process. Vanilla from the bean is so limited that it has become an unsustainable solution and as a result, vanillin sourced from vanilla beans makes up a very small percentage of its global flavor market share.

There are, however, other sources of vanillin available to meet demand. Many of these are produced from by-products of the oil industry. But not only are they less than ideal when it comes to flavor, they also are rapidly falling out of favor with today's more sophisticated – and clean-label minded – consumers, who demand natural and sustainable sources for the ingredients in the foods and beverages they enjoy. This is especially true of those products that evoke comfort, familiarity, and nostalgia, many of which include vanilla.

Spero Uses Non-GMO Corn to Produce Natural Vanillin



Vanillin at the source

Synthetic vanillin derived from petrochemical-based precursors makes up approximately 85% of the vanillin on the global market, with vanillin made from pine bark, wood pulp, cloves, and other plant sources accounting for around 15% of the vanillin available.

The ability to derive chemically identical vanillin from these other sources resides in the way the vanilla bean itself makes vanillin, through natural chemical precursors subjected to enzymatic and thermic reactions. Although vanillin can be created through a complex of chemical pathways, one primary precursor called ferulic acid can be created fairly easily through extraction of organic components that help make up the cell walls of certain plants such as corn.

New source crops up

Ferulic acid has been a known commodity since the 1980s. Soon after, it was discovered that through extraction, plant sources could be used to produce ferulic acid. This opened the doors to new natural sources of vanillin sustainably derived through fermentation – primarily, rice bran. However, there are distinct disadvantages that can arise from using rice as a source. Most rice-derived products, including rice bran-derived vanillin, are sourced and manufactured in Asia. In addition to traceability and quality control issues, rice grown in Asia has generated controversy over potential arsenic pollution.

Natural, with a nature-like taste experience

Spero Renewables, LLC has developed next-generation technology for producing natural vanillin from the ferulic acid extracted from non-GMO corn fiber. The company is currently the only producer of natural vanillin from corn in the U.S. Utilizing a natural process that conforms to all USDA and EU standards, Spero's vanillin can be labeled as "natural flavor," "non-GMO," and, depending on the corn fiber source, "organic."

Spero natural vanillin is an authentic product that is verifiable through isotopic fingerprint ($\delta^{13}C$ vs. $\delta^{2}H$). This makes it unique to other vanillin products in the market sourced from eugenol, rice bran, lignin, etc.

As a domestically grown and crafted ingredient, it is a reliable, fully traceable, clean and authentic vanillin with guaranteed consistency of quality. It is not subject to the issues of conflict and climate that can impact pricing and availability with non-domestic sources. It also has a significantly lower carbon footprint compared to other natural vanillin sources, since corn production requires less use of resources such as water and has lower transportation costs.

Green and clean

Unlike corn, which is cultivated across the U.S. and has a stable supply and price, most sources of rice are located overseas and supply is unpredictable. In fact, Bloomberg and other market watchers recently reported that due to weather disruptions and cutbacks from major rice producers, rice shortages are being forecast and prices are predicted to jump. Stable corn crops and abundant supply assure that Spero's natural vanillin will maintain its consistent high quality and competitive pricing (on par with or even lower than that of rice-bran derived vanillin, and about a third the cost of vanilla bean vanillin).

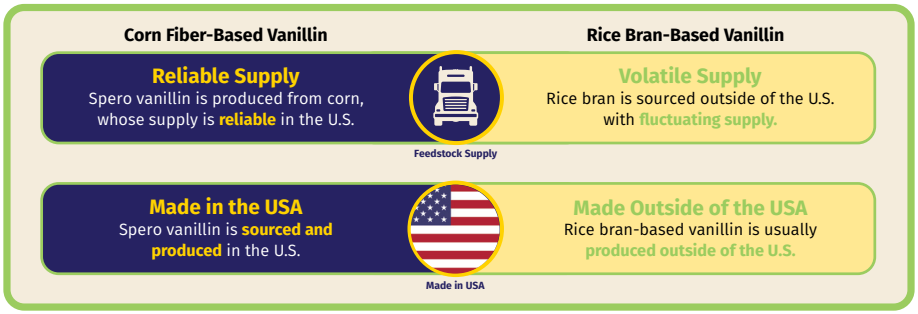
Comparison of Vanillin Raw Materials

Criteria \ Vanillin Source	Vanilla Bean	Spero Ferulic Acid from Corn	Ferulic Acid from Rice Bran	Clove	Curcumin	Catechol	Lignin
1. Natural Resources	✓ Vanilla Bean	✓ Ferulic Acid	✓ Ferulic Acid	✓	✓	X	X
2. Traditional Process	✓ Extraction	✓ Fermentation	✓ Fermentation	X	X	X	X
3. Final Substance Present in Nature	✓	✓	✓	✓	✓	✓	✓
	Natural Flavoring Ingredients						

✓ Compliant X Non-compliant

Spero vanillin conforms to both U.S. and European regulations as a natural flavorant and can be described as such on ingredient labels. For reference, those designations are: EC No 1334/2008 on flavorings for the E.U., and 21 CFR 101.22(a)(3) for the U.S. via Food and Drug Administration regulations.

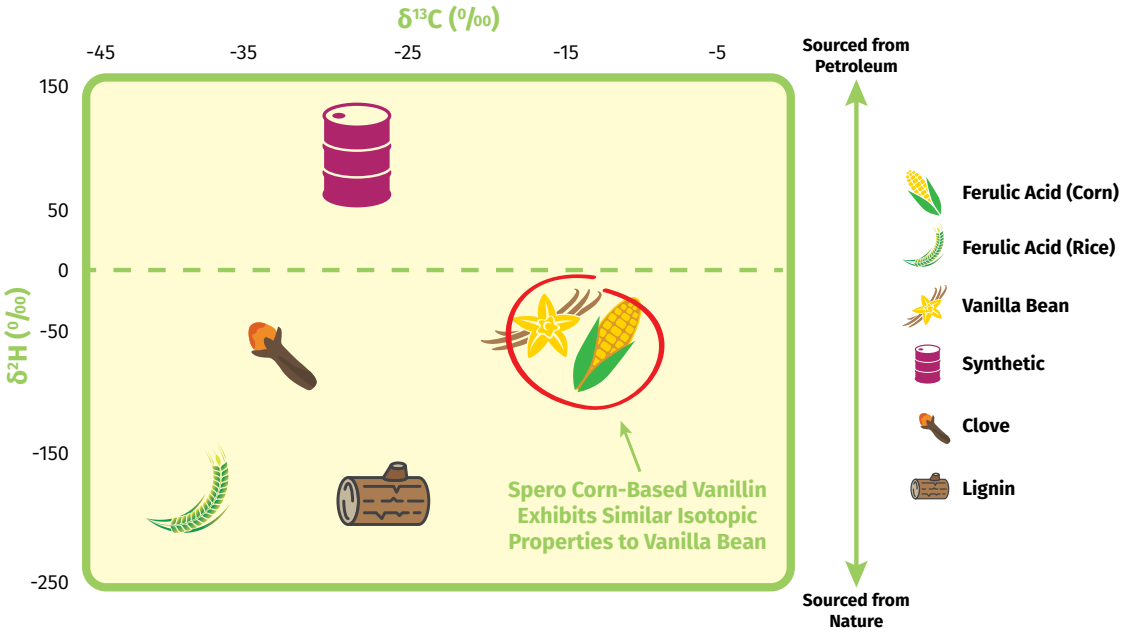
Corn Fiber-Based Vanillin vs Rice Bran-Based Vanillin



Meeting these requirements is not easy. For the E.U. certification, all raw materials for the ingredient must be derived from a natural source or natural source material. Then, the processing of that ingredient must be natural. Most importantly, the flavoring substance itself must be naturally present in nature. (Vanillin, of course, is naturally present in nature, and ferulic acid is present naturally in corn fiber.) Spero vanillin meets all three primary requirements.

As a fermentation-generated product, not only is Spero vanillin made from non-GMO corn, a non-GMO microorganism is used to convert the ferulic acid to vanillin through a traditional fermentation process. In compliance with the U.S. regulations, the raw material for the ingredient comes from corn fiber. The process used to make it is simple cooking and fermentation.

Authenticity: Isotopic Properties of Vanillin Ingredients from Different Sources



The demand for vanilla flavoring is continuing to rise. According to a recent report by Fortune Business Insights, “the global vanilla extract market is projected to grow from the current $4.94 billion to $6.29 billion by 2029, based on a CAGR of 3.52%.” Yet the combination of climate change and supply chain disruptions, coupled with the ever-growing consumer insistence on natural, sustainable foods and beverages will require a steady and reliable supply of real and consistent, high-quality vanillin. Spero’s vanillin from non-GMO corn fiber promises to bring that new natural vanillin to the table.

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