Would you wear yeast perfume? Microbes used to brew scent

Genetically engineered microorganisms could replace flowers as sources of ingredients for perfumes - and even recreate scents from plants long extinct

4 March 2015

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Scenting success
(Image: Fuhito Kanayama/Getty)

SITTING before me is a vial of cloudy white broth. Biologist Patrick Boyle invites me to take a sniff. To my amateur nose, the liquid smells green and sweet, a little like fresh-cut grass, a little like a bunch of flowers.

The concoction is a microbial perfume. Cooked up in the laboratories of Ginkgo BioWorks in Boston, it contains yeast that has been genetically engineered to smell of roses. Its ultimate purpose: to become part of a designer fragrance, one where its presence rivals the rose oils often used in luxury scents.

The "cultured rose" was born out of a marriage between Ginkgo – which bills itself as "the world's first organism engineering foundry" – and Robertet, a French flavours and fragrance company founded in 1850. Robertet prides itself on the natural ingredients it uses in perfumes created for clients such as Chloé and Bottega Veneta, as well as its scents for household products like detergents.

Rose oil is a classic perfume component. Traditionally, roses are grown in vast fields in Bulgaria or Turkey, then picked by hand and distilled to extract the aromatic oil. But from the fragrance companies' perspective, this approach is unreliable. Both the quality and the price of roses can fluctuate wildly from year to year, influenced by factors such as natural disasters, labour shortages, diseases or simply a poor growing season. "You have raw materials that will go from $10 to $100 a kilo because there's a shortage or an embargo," says Bob Weinstein, chief operating officer at Robertet.

Perfumers can use a synthetic substitute, created by mixing four or five chemicals together to approximate natural rose scent. This can be convincing, but some perfumers say it falls short of the rich subtleties that would distinguish a high-end fragrance.

Culturing microbes to produce scents is not only cheaper than using naturally sourced ingredients, but also gives perfumers more control over fragrances, says Ben Fundaro, director of perfumery at Robertet. "We're basically at the mercy of nature with some of these crops," he says. "If we could produce in a more controlled environment, the odour would be more consistent."

"We're at the mercy of nature with roses. Cultured products would give us a more consistent odour"

The approach being pursued at Ginkgo starts with the DNA of the rose itself. In order to make the compounds responsible for their flowers' distinctive smell (see "On the scent of a rose"), plants need to use enzymes, and the team must find the genes coding for these. Once that's done, Ginkgo can engineer a number of strains of yeast, each with a genome modified to ensure that the microbes' metabolic reactions result in one of the desired compounds. This might be accomplished by tweaking the genome or by adding genes from a rose or another plant, such as corn or hyacinth, that does the same job.

"Our goal is to recreate the rose biosynthetic pathways, even if we don't use rose genes to do ys Boyle. "We often find that a different but highly related gene from a different species s better in yeast than the rose gene that has the function we want."

Every month or so, Ginkgo sends samples of the strains to Robertet perfumers. They evaluate them and send critiques back to Ginkgo, asking for a scent to be made stronger or weaker, or to play up its floral, musky or fruity qualities. Once the strains for the individual components have been cleared by the perfumers, Ginkgo will produce a single strain of yeast that has all the genetic modifications – their attempt at the ideal rose scent.

The best rose oil, says Fundaro, smells fresh and clean, "very true to the way the rose would smell in the air if you were in a rose garden or next to a bouquet". One issue with the cultured rose fragrance is that it retains the yeast's characteristic sour smell. Before Boyle's team is done, they must find a way to downplay this odour, perhaps by moderating some of the genetic pathways that contribute to it, or by carefully filtering the final product.

Ginkgo isn't the only company to have anticipated manufacturers' desire for cultured fragrances and flavours. Californian company Amyris has partnered with Swiss firm Firmenich to work on lab-made patchouli oil. Allylix, another California company, cultures a version of vetiver oil, a woody extract of an Indian perennial grass.

"The basic material is sugar and microorganisms, so it's much more stable," says Toine Janssen, CEO of Isobionics, based in Geleen in the Netherlands. Isobonics relies on bacteria to make valencene, a compound found in oranges and often used in soft drinks. "It's like brewing beer. If you have lots of fermenters, you can make as much as you like."

Shota Atsumi, a chemist at the University of California, Davis, sees another potential upside to cultured products: they may replace some synthetic scents, the vast majority of which are produced from petrochemicals. Last year, in an effort to demonstrate the potential of cultured scents as a renewable alternative, Atsumi's research team altered the DNA of *E. coli* to make the bacteria smell like bananas and blueberries.

It's not clear what customers will make of a microorganism-cultured perfume. Victoria Frolova, a perfume industry analyst, says companies may choose not to highlight the unusual product process on the label. "For reasons of intellectual property, the fragrance industry doesn't share the components of perfume, much less how they are synthesised," she says. "How would anyone know that the molecules in their eau de toilette are yeast-produced?"

As researchers get better at producing cultured fragrances, they may become more adventurous, attempting to replicate much scarcer ingredients. Many natural fragrances prized by perfumers are extremely difficult to get hold of: compounds from jungle orchids that resist cultivation, for example. Another rare ingredient is ambergris, an earthy substance made inside a sperm whale's guts; people collect it whenever it washes up on the beach. These could one day be cultured by comparing the genomes of their animal and plant sources to already on tap in the lab.

Or fragrance companies could turn to bioengineers to order custom-grown versions of scents. This is the idea that excites Martin Gras, a perfumer for over 40 years. "Perfumers get inspired by nature," says Gras. "I can imagine with genetic engineering, you can make new odours just by changing the genes of the flower. It is another way of thinking."

The biologists at Ginkgo plan to push these boundaries. They are now seeking samples of Ice Age wildflowers that have been preserved in permafrost. If the surviving DNA fragments contain genes present in modern-day plants, researchers may be able to develop a yeast strain that mimics the extinct plants' long-lost fragrances.

"Can we recreate the scent of flowers that can't be grown because they don't exist any more?" asks Boyle. "People have sequenced Neanderthals, so it's not out of the question." Parfum Extinctio, the ultimate elite fragrance.

"Can we recreate an extinct flower's scent? We've sequenced Neanderthals, so it's not out of question"

On the scent of a rose

Why does a rose smell like a rose? To uncover the secrets of a flower's scent, chemists use a technique called headspace analysis. They lock the plant in an airtight glass container, trapping the volatile components responsible for its smell. It's then easy to do tests to identify each compound and measure its concentration.

Headspace analyses have revealed hundreds of compounds among the different rose varieties. The most common contributors to the classic rose smell are:

Citronellol Also found in citronella candles. Imparts a sweet smell.

Geraniol Strengthens the rose scent.

Nerol Makes roses smell fresh.

Farnesol This sweet-smelling compound in combination with the three above give roses their characteristic smell.

Linalool Often used in cleaning products with floral fragrances.

Eugenol Also found in bay leaves and clove oil, it has a spicy smell.

Rose oxide Has a grassy smell; strengthens roses' initial fragrance, or top note.

This article appeared in print under the headline "Yeast's heavenly potential"

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Magazine issue 3011 , published 7 March 2015