



Saffron

A Case Study on Use of Synthetic Biology Replacements



Farmers Affected: 150,000 farmers in Iran¹, 16,000 farmer families in Kashmir², 5,000 in Greece, 6,000 in Afghanistan, 1,200 in Morocco

Market Value: \$660 million US annual sales -
Based on current average market prices of \$2,000 US/kg³, 270 tonnes worldwide

Uses: Food, flavour, colour, medicine, perfumery

Syn bio Companies: Evolva

Hotspots: Iran (240 Tons/year)

Also Grown In: Greece (7.5 tons/year), India (Cachemire) (2.3 tons/year), Morocco (2.3 tons/year), Spain (1 ton/year), China (1 ton/year), Turkey, Kashmir and Afghanistan, Azerbaijan, Italy

Cultural Importance: Important religious, spiritual, medicinal, dietary and royal meanings. Drives tourism and represents local cultural identity and skills.

Biodiversity Considerations: Low water requirement, promotes pollinator population and habitats (natural pest control management and increased overall ecosystem services)

Quality Concerns: Natural saffron has at least 7 chemical constituents, and there are clear differences between the components of saffron grown in Iran and saffron grown elsewhere. Evolva are only synthetically producing a few constituents of saffron.

Patents: WO2015002528 A1, US20140248668 A1, US 7691406 B2, WO 2013021261 A2, WO/2015/162283, 20150093776

Products: None as yet

Method: Synthetically engineered yeast organisms

Commercialization: To be partnered, will delay launch to 2017 or later

Feedstock: Biomass

Brands, Identifiers: Unknown

Overview

Known for its rich scent and brilliant red and orange hues, saffron is the world's most expensive spice by weight. Saffron itself is the stamen, that is, the part where grains of pollen germinate, of the flower *Crocus sativus*. It is used in a variety of dishes, baked goods and liquors. Due to its high labor requirement, saffron is known to employ on average 200 person/days per hectare, employing a large percentage of women (80%). Its production affects more than 150,000 farmers in Iran, 16,000 in Kashmir, 6,000 in Afghanistan.⁵

Status: Syn bio saffron may be on the market in 2017



R&D

Scale Up

Commercialization

Evolva, a Swiss synthetic biology company, has successfully completed an R&D process to create bioengineered yeast that produce the key chemical compounds in saffron related to colour and flavour. Evolva is now able to make these compounds through fermentation of engineered yeast, bypassing the need for growing crocus flowers.



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

What is Saffron?

Saffron is the tiny harvested stamens of *Crocus sativus*, a widely grown variety of wildflower. Saffron is prized as a flavouring and coloring agent for food, in perfumery, and for medicinal and religious purposes. The chemical constituents of saffron include zeaxanthin, crocin and crocetin (colors), picrocrocin (bitter principle) and safranal (flavor).

Zeaxanthin is one of the most common carotenoid alcohols found in nature. It is the pigment that gives saffron and many other plants their characteristic color. Zeaxanthin breaks down to form picrocrocin and safranal, which are in large part responsible for the taste and aroma of saffron.

Saffron as a Natural Product

90-95% of the crocus flowers used to produce saffron are grown in Iran.⁶ It takes 150,000 crocus flowers and 40 hours of labor to manually extract enough stamens to yield 1 kilogram (kg) of saffron. After pistachio, saffron is Iran's most important non-petroleum export product. During harvest, each hectare devoted to saffron provides jobs for up to 270 people per day.⁷ Good quality saffron sells from \$2,000 to \$10,000 US/kg or more.⁸ Annual worldwide sales of saffron are an estimated \$660 million US.⁹ In 2009/2010, Iran's northeastern Khorasan Razavi province exported 57 tons of saffron worth \$156.5 million US to 41 countries.¹⁰ In 2014, Iranian saffron exports rose by 36%, despite international sanctions placed on the country.

Saffron cultivation in Kashmir, India forms an important sector for the livelihood security of more than 16,000 farm families located in 226 villages.¹¹ Herat Province of Afghanistan currently produces more than 90 percent of Afghanistan's saffron. 6,000 Herati farmers grow saffron and some 18 companies sell and export it abroad.

It provides job opportunities to women since they perform 80% of the cultivation and processing work. It also represents an important source of income and an alternative to poppy-growing.¹²

Greek saffron is regarded as particularly high quality by chefs around the world. It is produced mainly in Kozani County, in a cooperative of 1000 member families employing 5000 people.¹³ Saffron cultivation is important for both the growers, in terms of their farm income, and for the Greek agricultural economy, since all annual domestic production is exported.¹⁴

This crop also affects the livelihoods of around 1,200 farmers organized in Morocco's Taliouine Cooperative.¹⁵ Their city of Taliouine produces more saffron than any other place in Africa. Every November, harvest time is also time for their saffron festival, and people from around the world come to watch and celebrate.

Biodiversity and Cultural Considerations

The saffron crocus has been cultivated for some 4,500 years, and was likely selected from a wild population precisely because of its vigour as a hybrid, visible in its impressive corolla and stamens. Flowering crops contribute to natural pest control management, promoting bee population and pollinator habitat; they increase the availability of pollen and nectar resources, and provide secondary benefits to the farms and surrounding landscapes. Contribution to a pollinator habitat enhances overall biodiversity and the ecosystem services it provides, as well as contributing to human cultural values and rural aesthetic.¹⁶ Saffron is a plant with low water requirements and is perfectly adapted to a semi-arid environment that needs this kind of cash crop.

"Saffron can be cultivated in many areas. Economically, if each family had half a jerib or one jerib of land for saffron, we would be saved from poverty."

Bashir Ahmad Rashidi (head of the National Union of Saffron Growers of Afghanistan)⁴

Medicinal preparations based on saffron have been found on Egyptian papyruses dating from the 16th century BC. Once considered a cure-all, saffron is still part of Chinese and Indian medicine. As a dye, saffron yields a luminous golden hue that was used by the Greeks and Chinese. Pages of important manuscripts were illuminated by a precious dye of saffron mixed with egg whites.¹⁷ This crop is also strategically used as a tourist attraction in middle eastern countries.

Synthetic Biology Production

In 2010, Swiss-based synthetic biology company Evolva began working on a biosynthetic route to express saffron-derived genes in engineered microbes.¹⁸ The goal was to build a novel metabolic pathway that instructs cells to produce key saffron compounds, which are then inserted into a microbial host for large-scale production in fermentation tanks (bioreactors). According to the company:

“Producing the key saffron components by fermentation has three main benefits. Firstly, it will allow saffron to be available at a much lower price than currently, which will both expand existing markets and open new ones. Secondly it will eliminate the many complexities involved in the current supply chain. Finally, by making each of the key components separately, it will enable the production of customized forms that are for example particularly rich in aroma, taste or colour and that can be adapted to specific food formulations and regional preferences.”¹⁹

On March 30th 2016, Evolva published its financial results for 2015 and updates on coming projects. They announced, “We have successfully developed yeasts that make all three of saffron’s key ingredients and entered scale up fermentation. Saffron extract and safranal have Flavor & Extract Manufacturers Association (FEMA) GRAS (‘generally recognized as safe’) status and we are preparing a GRAS submission to FEMA for our product. We provided samples of some of our saffron products to a number of potential customers during late 2015 and received very positive feedback regarding its aroma and options for additional applications. In line with our revised company focus, we aim to further develop saffron with a partner. This will likely move the launch to 2017 or later.”²⁰

Implications and the Future

In conversations with ETC Group, Evolva has claimed that their saffron will not so much replace existing saffron market as open up new uses for saffron as a flavour, since it will be affordable for use in processed snacks and other low-price products. There may be something to this; but if Evolva’s saffron is sold as “natural” (because it is derived from fermentation) then it will be going head-to-head with current saffron markets.

Meanwhile the fortunes of botanical saffron on the world market are changing. Sanctions against Iran applied during the past decade have meant huge challenges for Iranian companies trying to export saffron to the US and Europe. However, in mid-January 2016 sanctions were lifted, allowing Iran to export freely to the US and elsewhere.²¹ The future is looking brighter for Iranian saffron farmers, unless a new competitor has emerged in Evolva. In that case they will have to deal not with sanctions but a new first supplier of saffron at much a lower price.

Endnotes

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