Naturally saffron-flavored rice? Here’s how scientists are using genetically modified tobacco and lemon to recreate the world’s most expensive spice

Biotechnology mass-produces valuable molecules from nature, from drugs to textiles to a jellyfish protein that lights up most anything a glowing green. Now add saffron to the list.

To cooks, saffron is a bright yellow spice derived from *Crocus sativus* flowers, aka “saffron crocus.” The dried red threads at the blooms’ centers are used to season and color foods. Popular for thousands of years, saffron comes today mostly from Iran. It’s used to infuse meats, grains, salads, and even to color marshmallows molded into baby chick shapes for Easter.

A method to produce saffron’s active ingredient derived from Gardenia on the left. On the right is saffron most expensive spice. Credit: King Abdullah University of Science and Technology

Saffron has medicinal potential. The main pigment crocin may be useful as a neuroprotectant, an antidepressant, a sedative, and an antioxidant.

Inspiring a Song

To those of us of a certain age, the word “saffron” conjures up “mellow yellow,” a 1966 song by Donovan:

> *I’m just mad about saffron*
> *A-saffron’s mad about me …*
> *They call me mellow yellow …*

We pondered the lyrics. Did mellow yellow refer to pot? LSD? Snorting roasted banana skins? None of the above, according to an article in Songfacts.

Said Donovan, the title and refrain mean “Being mellow, laid-back, chilled out. ‘They call me Mellow Yellow, I’m the guy who can calm you down.’ [John] Lennon and I used to look in the back of newspapers and pull out funny things and they’d end up in songs.” The lyrics are more about meditation than drug use, he said.

Saffron is the most expensive spice and is challenging to make: a kilogram requires 150,000 to 200,000 flowers. So finding a way to recapitulate nature’s saffron more economically has long been a goal.

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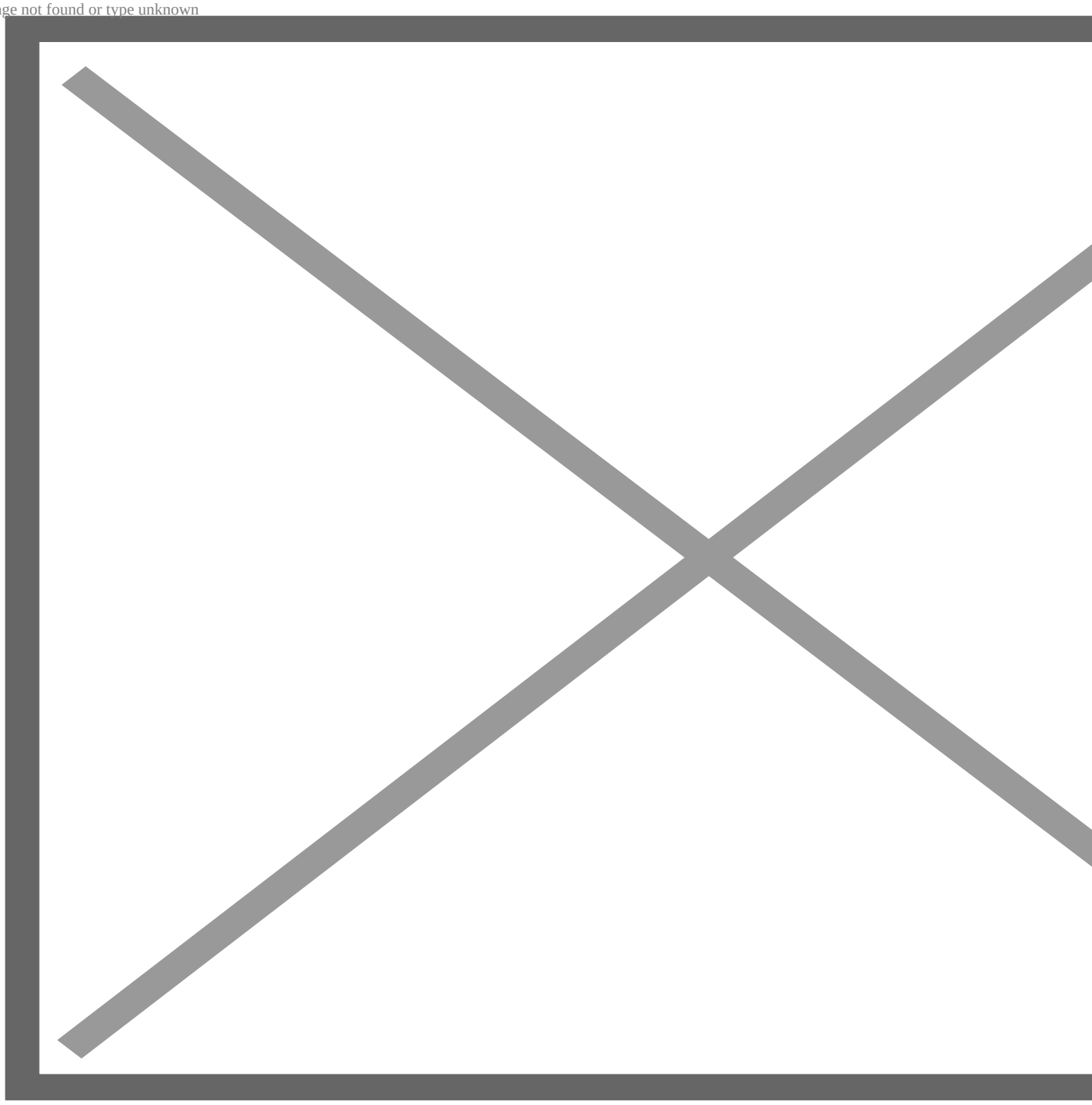

Parts and grades of Kashmiri saffron. Credit: A. Girme

SIGN UP

Now, Salim Al-Babili and colleagues at King Abdullah University of Science and Technology in Saudi Arabia have borrowed genes from a common gardenia plant to make the spice in cultured lemon lumps and leaves of a tobacco relative. These approaches are more true to nature than previous work that produced the plant pigment for study in cells of *E. coli*, a bacterium. The research appears in *Plant Biotechnology Journal*.

The Science of Saffron

Carotenoids provide the classic orange color of carrots and the hues of many other vegetables as well as fruits and flowers. We require these “phytonutrients” to activate vitamin A and for their antioxidant properties – a human body cannot synthesize them. In the plants, carotenoids protect chloroplasts, enabling photosynthesis.

But harvesting and processing hand-picked stigmas of *Crocus sativa* to get the saffron is labor intensive and the plant only grows in a few areas of the Mediterranean and Asia. The situation was ripe for a biotech solution, borrowing a bit of biochemistry from another species.

The strikingly yellow crocins come from the cleavage of carotenoids, and like all biochemical reactions is catalyzed – made fast enough – by the action of specific enzymes (carotenoid cleavage dioxygenases). The investigators used *Gardenia jasminoides*, an ornamental plant from traditional Chinese medicine that has small amounts of crocin and related compounds in the flowers. It’s easier to obtain.

. 8. 50% Ethanol extract of dried fruits Powder of *Gardenia*

Fig. 9. Amorphou ppt saffro

Extracts of gardenia and saffron. Credit: K. Thantsin

Specifically, the researchers harnessed two enzymes from the gardenia (phytoene synthase and beta-carotene hydroxylase). These enzymes catalyze carotenoid reactions, yielding crocins and also crocetin and picrococin, which are anti-oxidants with anti-cancer properties.

“The enzyme we have identified and the multigene engineering strategy could be used to establish a sustainable plant cell factory for crocin production in tissue culture of different plant species. Our biotechnological approach can also be used on crops, such as rice, to develop crocin-rich functional food,” said lead author Xiongie Zheng. The technology can also be used to produce carotenoid-derived scents and colorants.

CODA

Back when the recombinant DNA technology that lies behind the new source of saffron was new, in the late 1970s, many people objected, fearing the creation of what my PhD advisor then called “a triple-headed purple monster.” Instead, recombinant DNA technology has infiltrated medicine both human and veterinary; agriculture; textiles; biofuels and more. The global market is projected to hit a trillion dollars by

2030. Now the vibrant yellow saffron can join the list.

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