Research could lead to better-tasting tomatoes, other benefits

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(Phys.org) —Some compounds that determine plant species' characteristics such as the taste of tomatoes can be engineered to produce larger quantities in plants that have few or none of them, researchers at Purdue University have found.

Tomatoes available in the Northern states typically are grown in warmer climates, such as in Florida, California and Mexico, and harvested immature and still green so that they can ripen during or after shipment. But picking them before they are ripe affects their flavor, which has led to complaints from consumers.

"The research ultimately could lead to a variety of uses, such as in improving the taste of fruits including fresh-market tomatoes, in increasing the resistance of plants against pests or diseases, or in producing certain flavors, fragrances and pharmaceuticals," said Natalia Dudareva, distinguished professor of biochemistry.

The research involving metabolic engineering also was conducted by Purdue postdoctoral research associate Michael Gutensohn, with collaborators at the University of Michigan and in Israel. It was published in the August edition of *The Plant Journal* as the cover story.

Terpenes, a class of volatile compounds, are important because they often determine how fruits taste; how the flowers of a plant smell, thus attracting pollinators; and what characteristics plants might have to repel or defend themselves against pests.

The goal in the research was to determine how metabolic engineering can be used to produce large quantities of monoterpenes, a particular group of terpenes, to improve taste and aromatic qualities of fruits.

The researchers at Purdue used tomato fruits for their metabolic engineering studies to increase production of monoterpenes. Tomatoes are an ideal system for this research because during ripening they accumulate large amounts of carotenoids, the red pigment giving these fruits their characteristic color.

Carotenoids and terpenes are made from the same molecular building blocks, which allowed the researchers to tap into the pool of building blocks naturally available in tomato fruits and then engineer the production of monoterpenes.

The researchers learned that the largest quantities of monoterpenes were obtained through the combination of two enzymatic steps. In the first step, two of the available molecular building blocks are fused together to build an intermediate product. In the second step, the chemical structure of this intermediate is further modified, leading to the formation of monoterpenes.

More information: Cytosolic monoterpene biosynthesis is supported by plastid-generated geranyl diphosphate substrate in transgenic tomato fruits, Gutenshoh, M. et al.

ABSTRACT
Geranyl diphosphate (GPP), the precursor of most monoterpenes, is synthesized in plastids from dimethylallyl diphosphate and isopentenyl diphosphate by GPP synthases (GPPSs). In heterodimeric GPPSs, a noncatalytic small subunit (GPPS-SSU) interacts with a catalytic large subunit, such as geranylgeranyl diphosphate synthase, and determines its product specificity. Here, snapdragon (Antirrhinum majus) GPPS-SSU

was overexpressed in tomato fruits under the control of the fruit ripening-specific polygalacturonase promoter to divert the metabolic flux from carotenoid formation toward GPP and monoterpene biosynthesis. Transgenic tomato fruits produced monoterpenes, including geraniol, geranial, neral, citronellol and citronellal, while exhibiting reduced carotenoid content. Co-expression of the Ocimum basilicum geraniol synthase (GES) gene with snapdragon GPPS-SSU led to a more than threefold increase in monoterpene formation in tomato fruits relative to the parental GES line, indicating that the produced GPP can be used by plastidic monoterpene synthases. Coexpression of snapdragon GPPS-SSU with the O. basilicum a–zingiberene synthase (ZIS) gene encoding a cytosolic terpene synthase that has been shown to possess both sesqui- and monoterpene synthase activities resulted in increased levels of ZIS-derived monoterpene products compared to fruits expressing ZIS alone. These results suggest that re-direction of the metabolic flux toward GPP in plastids also increases the cytosolic pool of GPP available for monoterpene synthesis in this compartment via GPP export from plastids.

Provided by Purdue University

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