The molecular basis of strawberry aroma

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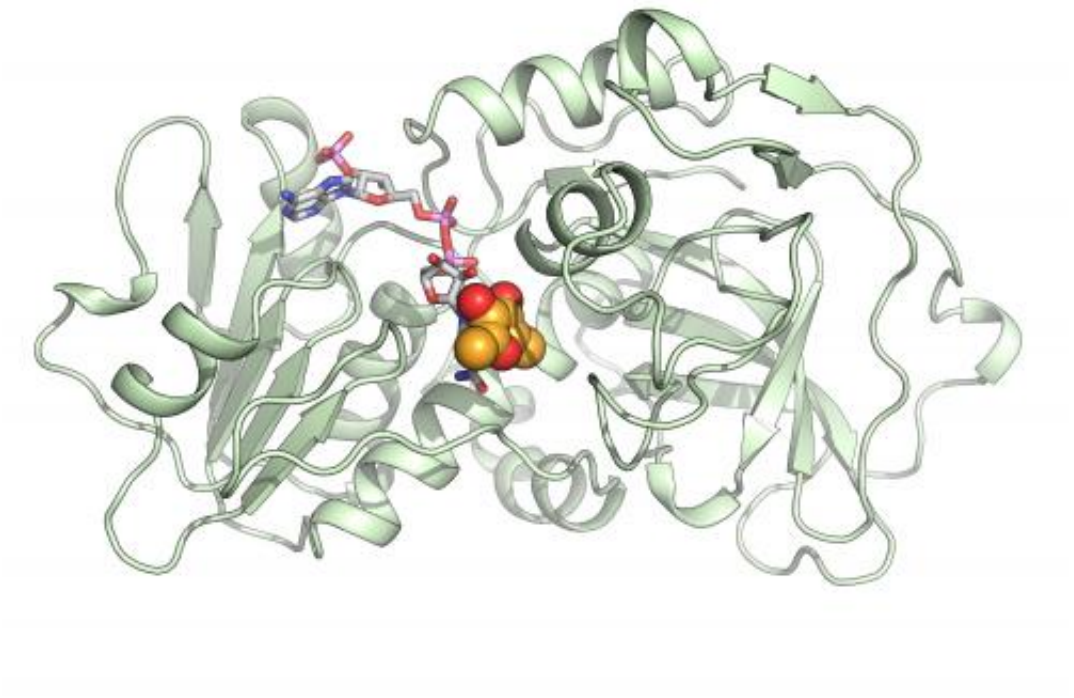


The precursor of the HDMF aroma compound (orange and red spheres) binds to the enzyme FaEO (green). The co-enzyme NADPH, depicted here as a multi-colored ball-and-stick model, provides the necessary electrons for the formation of HDMF, the key aroma compound of ripe strawberries. Credit: A. Schiefner/TUM

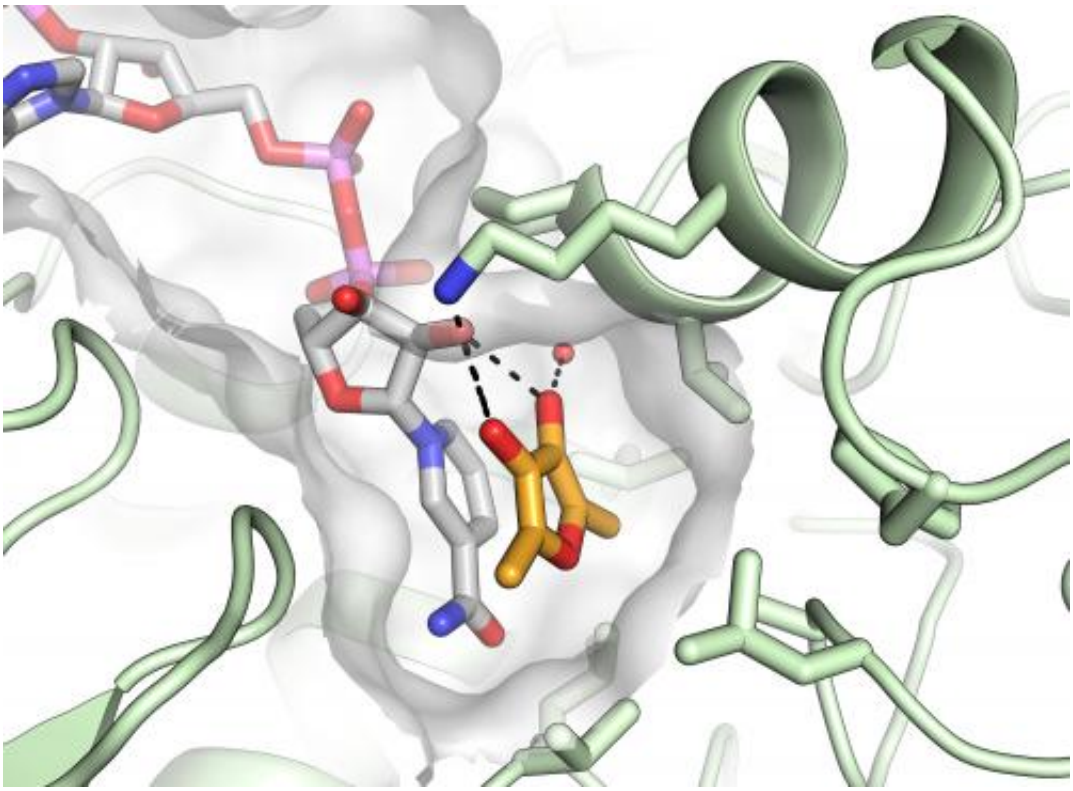
You know that summer is here when juicy red strawberries start to appear on the shelves. In Germany, this seasonal fruit has never been more popular: on average 3.5 kilos per head were consumed in 2012—a

full kilogram more than ten years ago. Scientists from the Technische Universität München decided to find out what gives strawberries their characteristic flavor.

It is not just our sense of taste that determines what a foodstuff "tastes" like. In fact, the tongue can recognize basic tastes like sweet, sour, salty, bitter and umami (savory). But to get that "rounded" taste experience, we also use our sense of smell – and strawberries provide a good example of this. The characteristic aroma of a fresh strawberry is the result of around a dozen different aroma compounds. One of these plays a particularly important role: HDMF (4-hydroxy-2,5-dimethyl-3(2H)-furanone), which is also known under the brand name Furaneol.

Prof. Wilfried Schwab, head of Biotechnology of Natural Products at TUM, who has spent many years researching the biological structure of this substance, explains: "A ripe strawberry has a particularly high concentration of this compound – up to 50 milligrams per kilo – which lies a far above the odor threshold. This compound gives the ripe fruit its characteristic caramel-like aroma."

HDMF is also found in pineapples and tomatoes. In plants, the aroma develops in a multi-step pathway from the from the fruit sugar fructose. "We were particularly interested in the biocatalytic process that leads up to the final compound," comments Prof. Arne Skerra from the TUM Chair of Biological Chemistry. In this process, a molecule precursor binds to the FaEO enzyme (Fragaria x ananassa enone oxidoreductase), which converts it into the final product, namely HDMF.



This detailed view of the substrate binding pocket (gray translucent surface) shows the transfer of two electrons from NADPH to the precursor of the HDMF aroma compound (orange-red ring structure). In this biochemical reduction reaction the HDMF aroma compound is formed. Credit: A. Schiefner/TUM

Molecular analysis reveals a new biosynthetic route

The TUM scientists were able to map this reaction path in detail. To understand how enzymes catalyze the biosynthesis of these new metabolic products, the research team took advantage of X-ray structural analysis. This allowed them to view the 3D structure of the molecules. "For the strawberry aroma, we investigated altogether six different enzyme-molecule combinations – and ended up understanding how FaEO produces the HDMF flavor compound," explains Dr. André Schiefner from the Chair of Biological Chemistry.

In the course of their research, the scientists discovered that the catalytic reaction involved a hitherto unknown mechanism. The compound is reduced and electrons are specifically transferred to a particular part of the molecule. Thus, the FaEO enzyme represents the first member of new class of biocatalysts – a discovery which could lead to useful applications in industrial biotechnology.

The latest research results provide valuable insight into the development of taste in widespread cultivated plants, as Skerra explains: "Unlike coffee or vanilla, the biochemical processes that produce the strawberry aroma are very complex. But now our TUM research team has shed light on an important step in its biosynthesis." Thus, biosynthetic processes might be used soon to prepare the true flavor of strawberry from fructose, for example to make drinks or food such as yoghurt taste even more like the real thing.

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