

Polyketide Synthase-like Functionality Acquired by Plant Fatty Acid Elongase

Background/Objective

Vegetable oils serve as critical feedstocks for biofuels and bioproducts by providing energy-dense hydrocarbon molecules. Some plants have evolved divergent enzyme sets to produce high-value "unusual fatty acids" with novel chain lengths or functional groups. The objective of this work is to elucidate and harness an unusual fatty acid biosynthetic pathway in seeds of *Orychophragmus limprichtianus* to expand the synthetic biology toolbox for plant/microbe-based bioproducts.

Approach

- Conducted advanced lipid analysis utilizing TLC, GC-MS, and LC-MS to identify and characterize the previously unknown fatty acids composition in seeds of *O. limprichtianus*.
- Combined biochemical assays and molecular biology with AI-guided protein structure modeling to better understand the molecular mechanism of biosynthetic pathway.
- Reconstructed the proposed biosynthetic pathway in an engineered oilseed host to validate enzyme functionalities in vivo.

Results

- Identified unusual fatty acids in *O. limprichtianus* seeds as C₂₄-C₂₈ keto-hydroxy fatty acids.
- Discovered that this distinct lipid profile is driven by two divergent enzymes: a fatty acid elongase 1 (FAE1) and a 3-ketoacyl-CoA reductase (KCR1).
- Revealed a biosynthetic pathway where the plant system acquires a bacterial polyketide synthase (PKS)-like discontinuous elongation functionality.

Significance/Impacts

This work reveals unprecedented evolutionary plasticity in plant lipid metabolism, breaking traditional boundaries of fatty acid engineering. We successfully reconstructed this pathway in an engineered oilseed host, establishing a powerful synthetic biology toolkit to produce high-value oil. This work provides a scalable bio-based source for industrial lubricants, which can support the bioeconomy.

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