

PLENARY PRESENTATIONS

ENGINEERING OILSEED CROPS FOR SUSTAINABLE PRODUCTION OF FUNCTIONAL FATTY ACIDS

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Plant oils are renewable sources of fatty acids with diverse biological, nutritional, and industrial applications. Our research focuses on developing plant-based production systems for two valuable types of fatty acids: hydroxy fatty acids (HFAs) and high-oleic oils. Using metabolic engineering and CRISPR/Cas9 genome editing, we have modified fatty acid biosynthesis and storage in *Arabidopsis*, *Camelina*, and soybean.

HFAs have unique chemical properties and are important raw materials for lubricants, polymers, nylons, cosmetics, and other industrial products. Castor (*Ricinus communis*) is the major commercial source of HFAs, but its seeds contain the highly toxic protein ricin. To develop safer alternative sources, we introduced multiple castor genes involved in HFA biosynthesis and triacylglycerol accumulation into *Arabidopsis*. Combined modification of fatty acid synthesis and elongation increased HFA accumulation to approximately 35% of seed oil. We subsequently applied this strategy to *Camelina* (*Camelina sativa*), where multigene expression combined with CsFAE1 genome editing and enhancement of lipid metabolic flux increased HFA accumulation to 26.4%.

We also developed high-oleic oilseed crops through genome editing of fatty acid metabolism. CRISPR/Cas9-mediated disruption of *FAD2* genes substantially increased monounsaturated fatty acids in *Camelina*. In soybean, combined editing of *FAD2* and *FATB* gene families increased oleic acid to over 92% while markedly reducing saturated fatty acids.

Together, these studies demonstrate that metabolic engineering and genome editing provide powerful approaches for redesigning plant oil composition. Our results establish oilseed crops as sustainable biofactories for the production of functional fatty acids with potential applications in food, biotechnology, and bio-based industries.