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Development of plant-based long-chain omega-3 oils

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Background:

Omega-3 long chain polyunsaturated fatty acids (ω3 LC-PUFA), in particular EPA (eicosapentaenoic acid, 20:5ω3) and DHA (docosahexaenoic acid, 22:6ω3), play a critical physiological role in health. They are nutritionally important for both humans and animals. Dominant resources of ω3 LC-PUFAs especially from wild-caught marine fish are declining and cannot meet the increasing global demand. Changing dietary preferences, contamination concerns and sensory experiences with fish oils are also contributing factors to why fewer than 20% of people worldwide are meeting the World Health Organizations recommended 500 mg daily intake of LC-PUFA.

Objective:

To develop oilseed crops producing ω3 LC-PUFAs to provide new sustainable and vegetarian sources of ω3 LC-PUFA for aquaculture and human nutrition.

Methods:

Genetic engineering of ω3 LC-PUFAs into oilseed crops involved survey of source microalgae, gene discovery, multiple-gene ω3 LC-PUFA synthesis pathway design, crop transformation and elite event selection. Additional TAG (triacylglycerol) assembly enzymes were introduced to change the positional distribution of DHA in TAG.

Results:

A large team effort contributed to the development of a canola crop with fish oil-like levels of DHA. The canola crop rich in DHA oil has been approved by multiple regulators in Australia, USA and Canada for large scale cultivation and the DHA-rich oil is approved for food and feed applications. Other plant-based long-chain omega-3 oils with different fatty acid profiles are also being developed. ω3 LC-PUFAs were dominantly distributed at sn-1/3 positions of TAG. Biochemical studies identified TAG assembly enzymes that showed preference for DHA from algae that accumulated high amounts of DHA. Further engineering these TAG assembly enzymes into DHA-producing seed enhanced the accumulation of DHA at sn-2 position and thereby increased the overall DHA level.

Conclusions:

Plant based ω3 LC-PUFAs production is achieved through engineering complex pathway into oilseed crops. Algal TAG assembly enzymes offered additional approach to accumulate DHA at sn-2 position of TAG thus increased the overall accumulation. These genetically engineered oilseed crops can help meet the increasing market demand for ω3 LC-PUFAs. The land-based source of ω3 LC-PUFAs offers a safe, cost effective, scalable, and sustainable future supply, which can have critical and positive health, economic and environmental impacts.