Engineered canola oil: a sustainable source of long-chain omega-3 fatty acids EPA and DHA

James Petrie[1] and Surinder Singh[1]
[1]CSIRO Food Futures National Research Flagship
Email: james.petrie@csiro.au

ABSTRACT

Omega-3 long-chain polyunsaturated fatty acids (ω3 LC-PUFA) have critical roles in human health and development with studies indicating that deficiencies in these fatty acids can increase the risk or severity of cardiovascular disease, inflammatory diseases and rheumatoid arthritis, hypertension and neuropsychiatric disorders such as depression or dementia. The main source of ω3 LC-PUFA is wild-harvest marine fish stocks. These stocks, however, are widely recognised to be in decline and although efforts are now underway to rebuild fisheries and improve their sustainability fisheries alone are unlikely to meet the growing global demand for ω3 LC-PUFA. Aquaculture cannot meet this demand since fish themselves do not produce LC-PUFA but instead accumulate LC-PUFA through their diet. In fact, the aquaculture industry itself contributes enormously to demand for LC-PUFA with around 90% of global fish oil production being used in aquafeeds. The major producers of ω3 LC-PUFA, microalgae, are a logical choice for increased production. The high cost of this method of production, however, means that such sources typically supply relatively niche and high value applications such as infant formulae and nutraceuticals. Alternative sources of these fatty acids must therefore be found. The microalgal genes responsible for ω3 LC-PUFA production have now been identified and isolated. ω3 LC-PUFA pathways typically include a minimum of five genes to convert the native plant fatty acids to DHA: Δ6-desaturase, Δ6-elongase, Δ5-desaturase, Δ5-elongase and Δ4-desaturase. Effort has now shifted from gene isolation to introducing these genes into suitable crop species and CSIRO has been able to demonstrate the production of significant levels of EPA, DHA and other LC-PUFA in plant oil. Figure 1, for instance, is a gas chromatogram traces of oil from a model plant, *Nicotiana benthamiana*, containing both EPA and DHA.

Oilseed crops, with their large production capacity and relatively low cost, could be a sustainable source of ω3 LC-PUFA. Current global fish oil consumption could be replaced entirely by 2.5 million hectares of an oil seed crop containing 10-15% of DHA and EPA in its oil. This would be approximately 2% of total world acreage under cultivation to major oil seed crops. Smaller-scale production would clearly be able to supplement the current fish oil sources to help meet growing demand. Unfortunately, oilseed crop plants do not naturally synthesise ω3 LC-PUFA so a metabolic engineering solution would be required before a potential oil seed crop source could become a reality. CSIRO, Nuseed and the GRDC have entered a collaboration designed to bring DHA-producing canola plants to Australian fields.

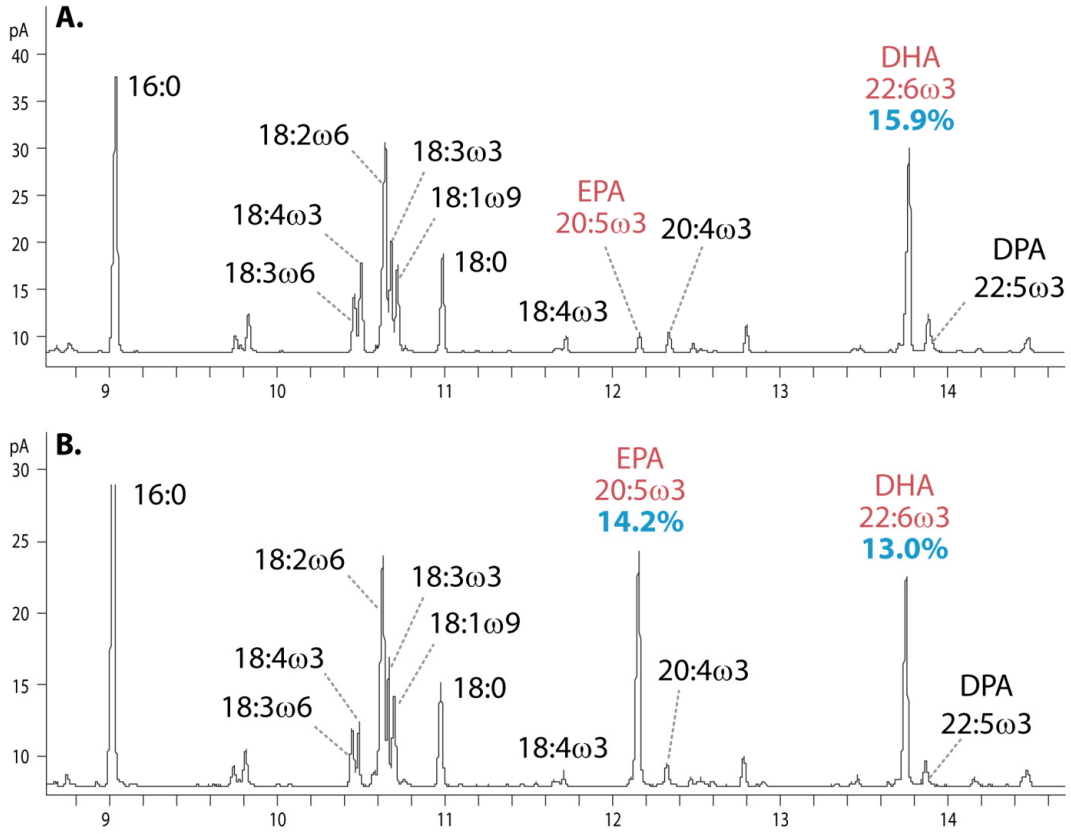

Fig 1. Production of EPA and DHA in *Nicotiana benthamiana* leaf oil.