Metabolic engineering of transgenic plants for the synthesis of omega-3 long chain polyunsaturated fatty acids- a terrestrial source of fish oils

Johnathan A. Napier, Noemi Ruiz-Lopez, Richard Haslam, Sarah Usher, Monica Venegas-Caleron, Olga Sayanova

Rothamsted Research, Harpenden, UK

There is now considerable evidence as to the importance of omega-3 long chain polyunsaturated fatty acids (LC-PUFAs) in human health and nutrition. Unfortunately, current sources are either in severe decline (fish oils) or expensive (via microbial fermentation), leading to the search for an alternative source. We have been evaluating the possibility of producing omega-3 LC-PUFAs in transgenic plants, to provide a sustainable source of these important nutrients, since no native higher plant species synthesise these fatty acids. Attempts to metabolically engineer plants with the primary biosynthetic pathway for LC-PUFAs has been carried out in both model plants and crop species, allowing insights into factors constraining the accumulation of these fatty acids. Specifically, a generic bottleneck resides within the primary LC-PUFA biosynthetic pathway as a result of the "substrate dichotomy" between the lipid-dependent desaturases and the acyl-CoA-dependent elongases which catalyze the primary reactions. This bottleneck can be overcome through the use of acyl-CoA dependent desaturase, though not without impact on phospholipid composition. The use of lipidomic analyses have also allowed us to start to model the flux of acyl-chains into triacylglycerols, pointing the way for further interventions in this pathway. The outcomes from recent iterations of our transgenic metabolic engineering will be considered, and the future prospects for GM-derived LC-PUFAs will be discussed.