With global fish stocks dwindling, researchers have intensified their efforts to find alternative sources of fish oils. A team at Rothamsted Research in the UK has run successful field trials sourcing omega-3 oil from genetically modified camelina

Gill Langham

Time to take

Photo: Rothamsted Research

Rothamsted Research's GM camelina produces over 20% EPA and DHA in its seed oil

The rise in demand for fish oils, with the sector currently estimated to be worth more than £5bn/year globally, is driving research into new sources of fatty acids.

Omega-3 long chain polyunsaturated fatty acids (LC-PUFAs), specifically eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), have been shown to be beneficial for human health and help protect against coronary heart disease.

The primary dietary sources of EPA and DHA are marine fish, from wild stocks or farmed fish (aquaculture).

Fish, like humans, do not produce these oils but accumulate them through their diet in the wild or through fish meal and fish oil in farmed fish. Around 80% of all fish oil is consumed by the aquaculture sector.

The aquaculture industry is seeking new sources of omega-3 LC-PUFAs to ensure its production practices remain sustainable and to nurture the essential aquatic food web.

One potential approach is to engineer a crop plant with the capacity to synthesise the fatty acids.

The team at Rothamsted Research, led by Omega-3 Flagship leader Prof Johnathan Napier, has spent nearly two decades working to meet this demand.

Promising results

In the trials, the Rothamsted team isolated the genes in marine microorganisms responsible for biosynthesis of omega-3 and identified *Camelina sativa*, one of Europe's oldest oilseed crops, as a plant host.

Recently published peer-reviewed results have been promising, showing that the accumulation of EPA and DHA in the seed oil of Rothamsted's GM camelina is stable, and importantly, the crop performs well in different environments and geographical locations.

"Current sources of EPA and DHA, the omega-3 long chain polyunsaturated fatty acids found in fish oils are at the maximum sustainable levels, yet the demand for these fatty acids is ever-increasing, mainly due to the needs of aquaculture.

"We have developed a GM plant which makes EPA and DHA and believe it could fill the gap in omega-3 supply and demand," says Prof Napier.

"Our current plant lines already produce over 20% EPA and DHA in their seed oil, and we are continually improving these

Photo: Rothamsted Research

The *Camelina sativa* plant has been identified as a source of omega-3 fatty acids, with Rothamsted Research in the UK running successful field trials of its genetically modified line of the oilseed

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levels. One potential target would be to have the same EPA/DHA levels as found in a high-quality Southern Hemisphere fish oil and we are already close to achieving that."

The research represents one of the most significant discoveries from the institute in the last 50 years, according to Prof Napier.

"If we can successfully make fish oils in plants, as opposed to having to take them from the oceans, this will be a big step forward in further improving the sustainability of aquaculture.

"Moreover, because our technology would harness the power and scalability of agriculture, the current constraints on the availability of fish oils would be removed. This means that many more people could have access to these health-beneficial fatty acids."

The use of GM

Rothamsted has been running field trials since 2014, and these have been getting progressively bigger each year.

For example, in 2017 trials totalling over 40,000m² were carried out in the UK, the USA and Canada. In 2019, the UK trial was over 4,500m², compared with less than 200m² in 2014.

GM technology was used for the oilseed, explains Prof Napier, as there are no plants that normally make EPA and DHA – although many plants make other forms of omega-3 fatty acids, such as ALA.

"Unfortunately, ALA does not have the same beneficial properties as EPA and DHA and can't substitute for them in either aquaculture or human nutrition.

"For this reason, we had to use GM technology to enable plants to now make EPA and DHA, by taking the genes from marine algae (which makes EPA and DHA) and putting them in our camelina."

The GM plants were made by using a bacterium called *Agrobacterium tumefaciens* to add the algal genes to the camelina. Agrobacterium is a natural genetic engineer, since it moves some of its genes from itself into plants, and we take advantage of this to add in our genes to camelina.

"We can then select for plants that are making the EPA and DHA omega-3 fish oils in the seed oil and propagate these plants.

"The nature of the genetic modification is stable, meaning that seeds from plants have the fish oil trait – as do their offspring, and subsequent generations," explains Prof Napier.

In some plants, the GM trait (the extra genes from the algae to make EPA and DHA) were combined with gene-editing (GE). In this case, the aim was to improve the fatty acid composition of the plants by using GE to block a pathway which competes for substrate in the synthesis of polyunsaturated fatty acids.

Rigorous assessments

Rothamsted has not experienced any significant opposition to its GM field trials or its research, according to Prof Napier, but it recognises that some people are opposed to GM technology in general.

"One could argue that such opposition is misplaced, given the prevalence of GM in medicines and other aspects of everyday life, but we believe it is a mistake to not respect such views and attempt to better understand them.

"We strongly advocate public dialogue as a mechanism to help explore opposing positions and the identification of common ground. In general, many of the concerns relating to GM plants are associated more with globalisation and corporatisation of the food chain, as opposed to specific objections to genetic technologies per se."

As part of the approval process to carry out GM field trials, Prof Napier explains that rigorous independent assessments are undergone to monitor any potential risk to either the environment or human health.

"Our GM and GE camelina have undergone such evaluations and are considered to not pose a risk to the environment," Prof Napier adds.

A marketable product

The sustainability credentials of a plant-based source of omega-3 fish oils are likely to be superior to those produced by other means, either wild capture of fish or fermentation of algae, says Prof Napier.

"A land-based source of these fatty acids would not only reduce the impact on marine fish stocks (such as Peruvian anchovy) which are harvested for these oils, but also reduce the environmental footprint on the oceans. Given the concerns about overfishing and pollution in our oceans, we believe that this is a significant benefit."

However, although the results from the Rothamsted trials are promising, there is still considerable work to be done to move this viable product from the experimental to the commercial phase.

"In reality, we are still several years away from being in a position to commercialise this technology. Whilst these experimental field trials are significant advances which serve to validate and de-risk our technology, a major step lies ahead with securing regulatory approval for full-scale cultivation and use as a feed and food.

"This would likely be sought in North America, since the regulatory system is well-established and much agriculture in that region already uses GM crops." ●

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