Plants could give the us the good oil

An innovative new project, established under CSIRO's Food Futures flagship program, plans to tap into Australia's existing crop production systems to produce large and sustainable quantities of key fish oils for human consumption and aquaculture.

The project aims to identify and transfer genes for essential omega-3 oil (fatty acid) production, from marine microalgae to oilseed plants such as canola or linseed.

Fish oils, particularly omega-3 long chain polyunsaturated fatty acids (PUFAs) such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), are essential in the diets of humans and a range of aquaculture species, including salmon and prawns.

With the decline in global fish stocks, alternative sources of fish oils are needed, both to eventually provide new sources for direct human consumption, and to meet demand from the rapidly growing aquaculture industry. According to the International Fishmeal and Fish Oil Organisation, if the current demand for fish oil continues to grow, it will outstrip wild supplies by 2010.

CSIRO Marine Research

Microalgae cultures are grown at CSIRO Marine Research to maintain an active collection for both scientific and commercial use.

Oil from microalgae

A common assumption is that marine fish synthesise omega-3 PUFAs themselves. In fact, it is marine microalgae that produce these essential fatty acids, which are then passed up the food chain. Over the past decade, scientists from CSIRO Marine Research have profiled the oil composition of a range of Australian microalgae housed in the CSIRO Collection of Living Microalgae. From this resource, Dr Stanley Robert and colleagues have selected a number of PUFA-producing microalgae, for genetic analysis.

'Microalgae that produce EPA, DHA and other omega-3 PUFAs, will contain genes for the production of these fatty acids,' Robert says.

'We aim to isolate these genes, study their function, and ultimately, express them in the seeds of important oilseed plants such as linseed or canola.'

New genes found

So far, the CSIRO team has discovered three genes that could be used to produce EPA or DHA in plants (see box). The function of these genes is now being tested in yeast. Once determined, Dr Allan Green and Dr Surinder Singh, from CSIRO Plant Industry, will verify that the genes work in two model plants: tobacco, and a tiny, fast-growing plant, *Arabidopsis*.

If all goes well, the team hope to achieve PUFA concentrations of 20–30% – the equivalent of PUFA concentrations in oily fish – in crop seeds. This oil could be

Oil production pathways

Omega-3 PUFAs are long-chain carbon molecules, characterised by the presence of a double bond between the third and fourth carbon atom. In biochemical terminology EPA, for example, is written as 20:5(n-3). This nomenclature describes a molecule that is 20 carbon atoms long with five double bonds, the first of which appears three carbons from the 'methyl' (CH_3) end, as follows:

(CH_3)-C-C=C-C-C=C-C-C=C-C-C=C-C-C=C-C-C-C-(HO-C=O)

Oilseed and crop plants produce some omega-3 PUFAs, such as alpha-linolenic acid [ALA, 18:3(n-3)], but not EPA or DHA [22:6(n-3)]. This is because they do not contain genes for the enzymes that 'elongate' (add carbon molecules) and 'desaturate' (add double bonds) PUFAs such as ALA, to form EPA or DHA. It is the genes for these 'elongases' and 'desaturases' that Robert and his colleagues are looking for. If these genes can be isolated from marine microalgae, they could be inserted into plants to drive the production of EPA and DHA from fatty acid precursors such as ALA.

CSIRO Plant Industry

Researchers hope canola will carry genes for Omega-3s.

'This research could see the production of a renewable resource using existing agricultural technology, that will enable farmers to value add their crops'

produced on a large scale for incorporation into salad dressings, margarine, juice, bread, milk, meat and eggs, and may provide people who don't like or want to eat fish, with a nutritious alternative. As there are not enough fish to sustain the current recommended dietary intake of PUFAs (2–3 serves per week), these products could also supplement the diets of fish consumers.

Similarly, plant-derived PUFAs could be used in aquaculture feed formulations, in combination with alternate protein sources such as lupin meal (*Ecos* 113), to reduce or replace the large quantities of wild fish that are ground up to provide the oil and protein needed to produce farmed fish.

While the project has only run for six months of a five-year vision, its potential is already apparent.

'This research could see the production of a renewable resource using existing agricultural technology, that will enable farmers to value add their crops, reduce pressure on fish stocks, sustain the growth in aquaculture, and provide more nutritious foods for human consumption,' Singh says.

● **Wendy Pyper**

More information:

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Waste plastic to clean fuel

An innovative solution, pioneered and commercialised in Japan, could help Australia reduce greenhouse gas emissions and the coal loads required by the iron and steel industries. Waste plastic will be used as a fuel in blast furnaces at iron-works, rather than heading for landfill, if a new scoping study by the Cooperative Research Centre for Coal in Sustainable Development (CCSD) confirms the process's feasibility.

In a traditional blast furnace, coal used to fuel the furnace acts as a 'reducing' agent for the conversion of iron oxide (FeO) into iron (Fe). This 'reduction reaction' occurs when carbon monoxide gas (CO), released from the burning coal, combines with the oxygen molecule from iron oxide to produce iron and carbon dioxide (CO_2). When plastic (a long chain hydrocarbon) is added, however, hydrogen molecules from the plastic combine with oxygen to produce water (H_2O), iron and reduced amounts of CO_2.

'This technology will only be practical in relative proximity to a blast furnace, of which there are three in Australia'

The plastic injection technology, successfully commercialised in Japan, helps reduce some 3.25 million tonnes of waste plastic buried in landfills each year. A ratio of about 10% plastic to coal is used in these commercial operations, but there is potential for this ratio to increase significantly. Before this happens, however, further research is needed to understand what happens inside a blast furnace when plastic is added.

The CCSD scoping study aiming to elucidate these unknowns is led by Professor Veena Sahajwalla of the University of New South Wales, in collaboration with BHP Billiton and Japanese scientists from Kyoto University and steel producer JFE.

'When you add plastic it changes the chemistry of the blast furnace,' Sahajwalla says.

'Water reacts more aggressively than carbon dioxide under high temperatures, and could cause other fuels in the furnace to degrade. So we need to identify the optimal ratio of plastic to coal and understand its impacts on the final product.'

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According to the Plastics and Chemicals Industries Association, more than one million tonnes of plastic was consumed in Australia in 2002. Of this, some 159 457 tonnes was recycled. The use of plastic as fuel in blast furnaces could help reduce its environmental impact.

The scoping study has not looked at chlorine-containing plastics, such as PVC, as these may generate undesirable by-products. However, Japanese scientists are working on this problem, the results of which could act as reference points for further development of the technology in Australia.

Estimates of the contribution of the technology to greenhouse gas reduction are currently being refined, as other 'eco-efficient' technologies are implemented concurrently.

The CCSD's chief executive Frank van Schagen says future development of the technology will consider how to source reliable plastic waste and who will pay for its collection and disposal. Because Australia is such a large country, collecting waste plastic on a national scale will be prohibitively expensive.

'This technology will only be practical in relative proximity to a blast furnace, of which there are three in Australia,' he says.

'However it is important to support research into this technology because, as customers for Australian coal increasingly adopt it, we need to understand the implications it will have on required coal properties and markets. The CCSD is also committed to the principles of increasing efficiency and reducing impact that underlie this technology.'

● Wendy Pyper

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