Public Release: 17 September 2004
THE PLANT CELL <http://www.plantcell.org>

Genetic Modification of Oilseed Plants Produces Healthier Omega 3 and 6 Fatty Acids

Improved Production of Polyunsaturated Fats in Oilseed Crops will Benefit Human Health and the Environment

In research reported this month in The Plant Cell, Ernst Heinz at the University of Hamburg (Germany) and colleagues succeeded in producing genetically modified linseed plants that accumulate significant levels of very long chain poly-unsaturated fatty acids (PUFA) in seed. The work is the result of an international collaboration between scientists at several research institutions in Germany (University of Hamburg, BASF Plant Science GmbH and Forschungszentrum Borstel), Rothamsted Research Station in the U.K., and Kansas State University in the U.S. This research is an excellent example of how genetic engineering of agronomically important species can provide real benefits to human health and nutrition and the environment. As demand rises for edible oils that are low in saturated fats and high in poly-unsaturated fats, in particular very long chain omega 3- and omega 6-poly-unsaturated fats, the production of these oils in plants may reduce environmentally and economically unsustainable pressures on both wild and farmed fisheries.

Fatty acids are long straight chains of carbon atoms, ranging in length from about 12 to 22 carbons (C12 to C22). They have one water-soluble end and one oil-soluble methyl end, and are studded with hydrogen atoms along the length of the carbon chain. They are essential components of the membranes of all living organisms. Fatty acid chains that are linked by single bonds between carbon atoms are said to be “saturated” by hydrogen atoms, whereas the introduction of double bonds between carbon atoms leads to correspondingly fewer bonds to hydrogen atoms along the chain, and such fatty acids are said to be “unsaturated”. A “mono-unsaturated” fatty acid contains a single double bond within the carbon chain, whereas “poly-unsaturated” fatty acids contain two or more double bonds.

PUFA are increasingly recognized as important components of a healthy human diet. Increased consumption, in particular of the very long chain PUFA such as those found in fish oils, has been linked to a decreased risk of heart disease, and also to a variety of other health benefits, including protection against inflammatory diseases such as arthritis, irritable bowel syndrome and some cancers, and the promotion of healthy brain and eye development in infants. Scientists have been working on engineering the production of the very long chain PUFA in plants, because increased consumption of fish and fish oils is associated with other nutritional and environmental problems. First, it is recommended that consumption of many types of fish be limited due to widespread contamination with pollutants, such as heavy metals and dioxins. Second, world wide fish stocks are being rapidly depleted, and fish farming is associated with its own set of environmental issues. Therefore, engineering the production of very long chain PUFAs into oilseed crops could confer significant advantages in terms of both human nutrition and the environment.

Oilseed crops, such as canola, safflower, and linseed, typically accumulate a high proportion of C18 PUFA such as linoleic acid and α-linoleic acid in their seed. These are

called “essential” fatty acids for humans, because they are not synthesized in the human body and must be obtained from dietary sources. Once consumed, they may be metabolized into very long chain (C20 and C22) PUFA in the human body. However, this process is slow and inefficient compared to the direct consumption of C20 and C22 PUFA that may be obtained from fish oils. Oilseed crop species contain all of the proteins and enzymes necessary for the biosynthesis of the range of fatty acids present in seed oil, but they lack the few additional enzymes (certain fatty acyl desaturases and elongases) necessary for the biosynthesis of very long chain PUFA.

Dr. Heinz and his colleagues produced linseed (*Linum usitatissimum*) and tobacco (*Nicotiana tabacum*) plants that synthesize very long chain PUFA in their seed by introducing genes for fatty acyl desaturases and elongases in genetic transformation experiments. First, protein sequences for fatty acyl desaturases and elongases were analyzed from a variety of organisms that produce very long-chain PUFA, including a fungus (*Mortierella alpina*), alga (*Phaeodactylum tricornutum*), moss (*Physcomitrella patens*), nematode (*Caenorhabditis elegans*), and another plant (*Borago officinalis*). DNA coding sequences for these genes were then introduced into linseed and tobacco plants, and expression of the proteins directed into the seed with the use of seed-specific gene promoter sequences. The best results were obtained with the use of the plant and algal gene sequences. These transgenic plants accumulated significant levels of very long chain PUFA in their seed. Analysis of fatty acid profiles of these plants also allowed the researchers to identify constraints on the accumulation of the most desirable PUFA, pointing the way to future experiments aimed at making improvements in the levels of accumulation and specific profiles of very long chain PUFAs in genetically modified oilseed crops. In addition to the possibility of providing healthier, more nutritious oils for human consumption, this work will lead to the production of high quality animal feed that could improve the PUFA content of animal products such as meat, eggs, and dairy foods.

This research is the result of an international collaboration between scientists at the University of Hamburg, BASF Plant Science and Forschungszentrum Borstel in Germany, Rothamsted Research station in the U.K. and Kansas State University in the U.S. Funding was provided by grants from the German BMBF-Projekt NAPUS 2000 and BASF Plant Science GmbH (Ludwigshafen, Germany), with additional support from the Kansas National Science Foundation Experimental Program to Stimulate Competitive Research (EPSCoR).

Contacts: Nancy Eckardt neckardt@aspb.org 970-495-9918

Amine Abbadi abbadi@botanik.uni-hamburg.de +49-40-4281-6375

Ernst Heinz eheinz@botanik.uni-hamburg.de +49-40-4281-6369

The full research paper cited in this report is available at
http://www.aspb.org/pressreleases/Oct026070.pdf