OVERVIEW ON APPLICATION OF BIOTECHNOLOGY TO NUTRITION

George MOISE

"Lucian Blaga" University of Sibiu
Corresponding author: georgemoise@yahoo.com

Abstract: *Crop biotechnology is being used to enhance the productivity of crops important for the developing world, with the aim of improving food security. The nutritional composition of crop foods can be improved via biotechnology using processes like carotenoid or oleic acid enhanced vegetable oils. Also, food crops can be genetically improved by reducing their allergens and can become vehicles for vaccines against life-threatening diseases. Human milk proteins can be expressed in plants as a means to produce improved infant formulas.*

Key words**:** *Crop biotechnology, milk proteins, nutritional composition*

INTRODUCTION

Several on-going projects in Africa, Asia and Latin America where crop biotechnology is being used to enhance locally grown crops. The expectation is that genetically improved crops, e.g., those able to resist local pests, will allow even small-scale farmers to grow more crops using fewer inputs and in an environmentally sustainable manner. A few of these projects are described in this paper.

HIGH CAROTENE MUSTARD SEED OIL

"Golden Rice," the rice genetically enhanced to express carotenoids, has received much media attention because of its potential to supply a desperately needed nutrient, vitamin A, to millions of malnourished people. Developed in the 1990s by researchers in Germany and Switzerland with financial support from the Rockefeller Foundation, the laboratory lines of Golden Rice must now be transferred to local rice varieties. Initial efforts are focused on India, but arrangements have also been established in SE Asia, China, Africa and Latin America to transfer the technology. Although commercialization of Golden Rice is still several years in the future, a commitment has been made to make the product available free of charge to small-scale poor farmers of developing countries.

A similar project has been initiated by Monsanto Company, in cooperation with Michigan State University, USAID and the Tata Energy Research Institute in India. The project was developed in part to respond to a greater effort to enlist private sector collaboration in the Global Vitamin A partnership program, which was initiated by then First Lady Hillary Clinton. Monsanto developed the technology to insert the enzymes of the phytoene synthase pathway into *Brassica napus* (canola). Concentrations of 1000–1500 μg carotenoids/g fresh weight of seeds were achieved.

This technology now is being transferred into *Brassica juncea* (mustard), a relative of canola. *Brassica juncea* is grown in many parts of the world, including India, Nepal and Bangladesh, and it provides the second highest consumed oil in India. The resulting mustard seed oil is expected to contain adequate beta-carotene to have an impact on Vitamin A deficiency in the Indian population. And since it is in an oily medium, it is expected to have good bioavailability.

It is important to realize that the first crops developed via biotechnology appeared on the market only six years ago. While these first products were intended to benefit primarily farmers and consumers in the developed world, the examples cited above show that biotechnology is being applied for the benefit of populations of the developing world. In the next several years, we will see the application of biotechnology to improve major global staples, such as rice, wheat, corn and cassava grown in Asia, Africa and Latin America, which will be needed to feed the expanding populations in these continents. A case in point is the application of Bt-based pest resistance technology to corn in Kenya. Kenyans consume 175-275 pounds per capita of corn, yet experience losses of 15% to 45% of the crop, equivalent to 400,000 tons and valued at $90 million. In 1999 the International Maize and Wheat Improvement Center (CIMMYT) and KARI launched a project to use Bt technology to develop corn adapted to Kenya's agro-ecological zones and resistant to pests such as stem borers. Similarly, in the Philippines, resistance to stem borers has been achieved in rice by inserting the Bt gene. Since rice forms the basis of the Asian diet and the population is rapidly expanding, additional strategies such as Bt rice should help meet the increasing demand for this staple.

CROP BIOTECHNOLOGY TO ENHANCE NUTRITIONAL QUALITY

The nutritional concerns of westernized populations stem from the quality and composition of foods rather than from inadequate quantity. For example, the recognition that *trans*-fatty acids found in foods containing hydrogenated vegetable oils and shortenings may have undesirable effects on blood lipids has caused the food industry to reexamine its use of these ingredients. One solution would be to use oils or shortenings rich is stearic acid, an 18-carbon saturated fatty acid that does not have undesirable effects on blood lipids. Via biotechnology, canola has been made to over-express stearic acid by repressing the **Δ**9 desaturase enzyme; the resulting vegetable oil requires little or no hydrogenation, has no *trans*-fatty acids and provides the food processing qualities of a hydrogenated oil without the hydrogenation process. While such a product could provide a solution to the food processing industry, current fatty acid labeling regulations provide a disincentive to the use of such a product. Because the U.S. FDA requires that the stearic acid content of a product be reflected in the saturated fat declaration in labeling, the substitution of high stearic acid oil for a hydrogenated oil in a processed food product could result in an increase in saturated fat content of the product. Furthermore, the FDA has proposed that a *"trans-free"* claim cannot appear on the labeling of products that contain more than 0.5 g saturated fatty acids. Since consumers understand that saturated fats have undesirable effects on blood lipids and should be limited in the diet, a product with more stearic acid, even though it does not elevate lipids, will be represented negatively in labeling.

Another approach to improve the functional properties of vegetable oils while avoiding hydrogenation and the generation of *trans-fatty* acids is to over-express oleic acid (18:1 n-9) at the expense of linoleic (18:2 n-6) and linolenic acids (18:3 n-6). The reduction of polyunsaturateds makes the oil less susceptible to oxidative rancidity, an important consideration in food processing and food service applications. By silencing the gene for the A12 desaturase enzyme, oleic acid conversion to linoleic acid is minimal, and instead oleic acid accumulates in the oilseed. Soybean oil with 85% oleic acid and less than 5% total polyunsaturated has been produced via this transformation process, and the oxidative stability of the oil was shown to be similar to that of a fully hydrogenated frying shortening.

As of this writing, there are no commercialized food products of biotechnology containing animal or human genes. The technology is available, but public acceptance issues may be deterring their development. Nevertheless, researchers at the University of California at Davis have succeeded in inserting and expressing the genes for several human milk proteins - lactoferrin, lysozyme and the alpha-1 antitrypsin protein - in rice for the purpose of improving infant formulas. Such a product could provide a test case for the debate over whether there are socially acceptable circumstances where human genes could be used in commercial, genetically enhanced food products. Such products also would necessitate the development of policies and practices to assure that rice (or any other vehicle) containing human proteins would be segregated from the general food supply and that pediatricians and consumers would be fully informed about the product.

There has been much concern in the media and among consumer activist groups about the possibility of inadvertently inserting an allergen into a genetically enhanced crop, causing it to be allergenic to certain people. Developers of genetically improved crops take several measures to assure the risk of such an inadvertent event is very small. The "flip-side" of this situation is that genetic engineering techniques are being used to reduce, if not eliminate, allergens in food. For example, workers in Japan have reduced the content of an allergenic protein in rice by silencing the gene expressing the protein. Other researchers are working to reduce the allergenicity of peanuts and wheat.

Genetic engineering techniques are also being used to put vaccines in foods. Potatoes have been developed to contain vaccines against a variety of diseases, including cholera, Norwalk virus and hepatitis B. One draw back from the use of potatoes as the vehicle is that they must be eaten raw. Dr Charles Arntzen, a pioneer in this field, is now inserting a vaccine against hepatitis in bananas, a more palatable vehicle when eaten raw and a food that can be readily eaten by small children. The benefits of food-borne vaccines are that they could be provided for a fraction of what it costs to develop and administer vaccines as injections. However, there are many questions about how these products would be controlled, so again new policies and procedures will need to be developed. Issues such as proper distribution, quality control and control of access will need to be resolved.

CONCLUSIONS

Almost all these crops were developed to provide pest protection or herbicide tolerance to crops grown primarily in the countries of the developed world. However, we are already seeing examples of crops genetically modified to improve yields of crops grown in the developing world as well as to improve the nutritional content of crops grown in all areas of the world. Other anticipated benefits to consumers include reduced allergenicity of foods as well as expression of high value proteins in foods. The introduction of such new products will require the development of new policies and procedures to assure their safe and appropriate introduction into the marketplace.

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