

## Health Benefits and Risks of Genetically Modified Foods

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### ABSTRACT

Genetically modified (GM) foods have been the subject of much controversy. The technology is causing changes in food production at a rate that is faster than our understanding of their potential impact on human health. The efforts to produce GM foods have been motivated by the need to help provide more food for the world's continually increasing population and to provide foods that look and taste the same as present foods, but promote better health through improved nutritional characteristics. The potential problems for human health and safety associated with GM foods are not clear-cut. There have been fears that new genes introduced into foods can cause toxic or allergic effects in people. However, there are not a large number of potential allergens in the market place. Based on present evidence, the benefits of GM foods are likely to be more than the risks but there is still the need to fund research that will help understanding in order to properly address the issue of GM foods.

**Key words:** genetically modified food, genetically modified organism, allergenicity.

### RESUME

Les aliments génétiquement modifiés (AGM) ont été l'objet de beaucoup de polémique. Le développement technologique cause des changements au niveau de la production des aliments à une vitesse plus rapide que la compréhension de leur potentiel impact sur la santé humaine. Les efforts pour produire des aliments génétiquement modifiés ont été motivés par la nécessité de produire quantitativement plus de nourriture eu égard à l'augmentation drastique et continuels de la population mondiale, et afin de fournir des aliments identiques à ceux consommés actuellement point de vue goût et présentation, mais qui par une amélioration des caractéristiques nutritionnelles, favoriseraient une santé meilleure. Les problèmes potentiels de salubrité et d'innocuité des aliments liées aux aliments génétiquement modifiés ne sont pas bien définis. Il y a eu des craintes que les nouveaux gènes présents dans les aliments puissent être à l'origine des effets toxiques ou allergiques chez les humains. Cependant, il n'y a pas un grand nombre d'allergènes potentiels sur le marché. Basé sur l'évidence actuelle, les avantages des aliments issus de AGM sont susceptibles d'être plus importants que les risques y afférents, mais il demeure nécessaire de financer la recherche qui aidera à comprendre et aborder correctement la question des aliments issus de AGM.

**Mots clés:** aliments génétiquement modifiés, organismes génétiquement modifiés, allergènes.

## INTRODUCTION

Genetically Modified (GM) food is a topic of great interest and it is at the cutting edge of biotechnological science. It has raised concerns about technological advances in food production to an unprecedented level and it has proved difficult to hold a balanced and objective debate (BMA, 2003).

According to the World Health Organisation (WHO, 2000), genetically modified organisms may be defined as organisms in which the genetic material has been altered in a way that does not occur naturally. The technology is often called "modern biotechnology" or "gene technology", sometimes also "recombinant DNA technology" or "genetic engineering". It allows selected individual genes to be transferred from one organism into another and it can even be done between non-related species. Such genes are used to create GM plants or animals, which are then used to grow GM Food crops or animals and hence GM Foods.

By modifying the genes, scientists can alter the characteristics of an animal or organism. This could be to boost crop yields, increase resistance to disease or in the case of animals to increase bulk or muscle. The development of new and successful plant varieties or animals by traditional techniques may take several years (Orf, 1988). For example, the development of canola oil seed crops by traditional techniques required 15 years but the development of new genetic engineering oilseed crops took less than half the time (Lui and Brown, 1996).

The first GM crops were introduced in the early 1990s. Some of the common GM food crops are maize, soybeans, potatoes, tomatoes, cotton and canola. Transgenic GM crops have been developed. One third of the corn and one half of the soybeans produced worldwide are transgenic. Early GM crops were developed to resist insects and disease, and to tolerate harsh climate conditions and herbicides (James, 2000). Recent traits of GM crops that confer consumer benefits such as increased nutritional value, improved taste, longer shelf life and reduced toxicity are being selected. The ensuing overview focuses on the human health benefits and risks of bioengineered foods, especially in the area of biofortification of vitamin A and Iron rice, designer oils from oilseed crops, allergenicity and nutritional status.

## BENEFITS OF GENETICALLY MODIFIED FOODS

GM foods have been the subject of much controversy. Advocates feel that GM foods will help provide food to the world's continually expanding population. Since the number of people on earth keeps increasing (over 6 billion, and expected to double within 50 years), and the amount of land suitable for farming remains constant or is decreasing, more food must be grown in the same amount of space. Genetic engineering can make plants or animals that will give farmers better yields through several different methods (James, 2000).

Malnutrition, especially undernutrition adversely affects the life, development, and health of more people throughout the world than any disease. Malnutrition results from the intake of too few calories, too little high quality protein, and multiple deficiencies of minerals and vitamins (Krause and Mahan, 1979). For nutritional deficiencies like iron and vitamin A, it is difficult for many poor people in the developing countries to reach the required daily intake, as they do not have access to enough food that is high in vitamins and minerals. Up until now, fortification, increasing the level of nutritional value in foods, has been popular in many western countries, but it is often expensive. Due to the increased cost in fortifying food, it is sometimes difficult to reach all groups in society because the extra cost makes it difficult for some low-income groups to purchase the higher priced fortified food. Fortification is less practical in less developing nations where the diet is usually locally produced (Combs et al, 1997). Through the use of GM technology, food could be altered to increase the amount of nutrients present to help meet the recommended daily nutritional intake for the average person. Genetically modified foods are currently being developed to both improve nutrition and prevent disease in children and adults. Examples of genetically modified foods, which could improve on health, are vitamin A and iron enhanced rice and designer oils from oil seeds. This could be the sustainable solution to malnutrition in developing countries, whose aim is to provide sufficient quantity of high quality diet to its population.

### Vitamin A and Iron enhanced rice

Vitamin A and Iron deficiency remain among the most serious nutritional disorders worldwide. Infants, children and women of childbearing age are

the most vulnerable. Vitamin A is essential for the operation of the body's immune system, reproductive function, bone growth and is responsible for protecting mucous membrane cells. Vitamin A deficiency causes blindness in 250 million children each year among which 500,000 cases are irreversible. Some 3.7 billion people have iron deficiency, half of which are anaemic (Friedrich, 1999). In the third world, 30 to 60% of women and children are anaemic (Yip, 1997). Without iron, the body cannot make haemoglobin. The main causes of iron deficiency anaemia are: iron-poor diet, blood loss, inability to absorb iron and increased requirements for iron during certain stages of life (infancy, adolescence, and pregnancy).

Many countries in the world rely on rice as their primary food source. Unfortunately, rice as currently grown lacks many essential vitamins and minerals. As such, people whose diet is based on rice are malnourished. Conventional rice grains contain phytic acid that can prevent the human digestive system from absorbing iron. The most severe consequences of this are blindness and anaemia caused by vitamin A and iron deficiency respectively. Iron deficiency anaemia is considered to be the most widespread deficiency syndrome worldwide. According to UNICEF over 2 billion people suffer from iron deficiency. Until now, these deficiency symptoms could be only partially remedied by food supplements or vitamin and mineral enriched foods. The strategy for genetically enhancing dietary iron in rice (biofortification) involved optimising iron uptake on three different levels. The iron content is increased, bioavailability of iron is improved and iron absorption inhibition is decreased (Lucca et al., 2001). One rice gene has been modified and two new genes, coming from green beans and a specific microorganism, have been implanted into the rice plants used at the ETH in Zurich. The result is that the iron content of some plants has been doubled. Dietary vitamin A occurs in two forms: retinal and carotenoids. Enhancement of vitamin A content of foods is limited by the toxicity of its metabolites. Retinol is toxic at only 5-fold RDA levels of intake. The maximum safe intake of  $\beta$ -carotene is 20 times that of retinal. Large doses of  $\beta$ -carotene are not converted to vitamin A rapidly enough to produce vitamin toxicity. Genetic production of  $\beta$ -carotene content instead of retinal content was chosen as a means of increasing vitamin A. Four genes (two from the

*Daffodil* plant and two from the bacterium *Erwinia uredovora*) were introduced into the rice genome to encode proteins necessary for synthesis of  $\beta$ -carotene (Perr, 2002). Due to the introduction of two other genes, the vitamin A precursor ( $\beta$ -carotene) has now been stored in husked rice. Some genetically modified plant lines contain sufficient provitamin A to satisfy daily vitamin A requirements with 300g of cooked rice. Researchers at the Swiss Federal Institute of Technology for Plant Sciences have put this technology into practice by genetically producing rice, which is high in vitamin A and iron (Yip, 1997). Once possible risks to human health and environment are assessed, the rice will be distributed for free to any third world country requesting it (Potrykuss, 2001).

### Designer oils from oilseed crops

As some parts of the world suffer from too little food and lack of specific nutrients (undernutrition), other areas suffer from excess food and an inappropriate balance of nutrients (overnutrition). The United States Department of Agriculture (USDA) food consumption survey of 1987-1988 indicated that American children consume 35 to 36% of their total calories as fat, which is higher from the recommended 20 to 30% of total calories. The children consume 14% of total calories as saturated fat as in contrast to the RDA of less than 10% (NIH, 1991). Excessive and inappropriate fat intake has its consequences. The risk of chronic diseases such as cancer, hypertension, myocardial infarction, stroke, obesity and atherosclerosis has been associated with high fat diet. This is also linked with childhood obesity (Dietz, 2002). Thirteen million Americans have coronary heart disease, which causes 1.5 million myocardial infarction and 450,000 deaths annually (Grundy, 1981).

Both the type and amount of fat are important determinants of disease risk. Oilseed crops are already being genetically modified to contain low saturated fatty acids and increase unsaturated fatty acids. Genetic engineering has also been used to produce oilseed crops with more stable oils and those with a reduced need for hydrogenation (Thelen and Ohlrongge, 2002). The amount of stearic acid has been increased as much as 40% in oilseed to produce a semisolid, which requires no hydrogenation (Lui et al, 2000; Hawkins and Kridl, 1998; Kenney, 1996).

## RISKS OF GM FOODS

It is more difficult to evaluate the safety of crop-derived foods than individual chemical, drug or food additives. Crop foods are more complex and their composition varies according to differences in growth and agronomic conditions. Publications on GM food toxicity are scarce. In fact, no peer-reviewed publications of clinical studies on the human health effects of GM food exist. Even animal studies are few and far between. The preferred approach of the industry has been to use compositional comparisons between GM and non-GM crops. When they are not significantly different the two are regarded as "substantially equivalent", and therefore the GM food crop is regarded as safe as its conventional counterpart. This ensures that GM crops can be patented without animal testing (Pusztai, 2001). This may not be a very good approach because substantial equivalence is an unscientific concept that seemed not to have been properly defined and there are no legally binding rules on how to establish it. However, the assessment of GM foods with enhanced nutritional properties should focus on the simultaneous characterization of inherent toxicological risks and nutritional benefits.

### *Allergenicity*

An allergy is a hypersensitive condition acquired by exposure to an allergen. Food allergies are adverse reactions to an otherwise harmless food or food component that involves an abnormal response of the body's immune system to specific protein(s) in foods. True food allergies may involve several types of immunological responses (Sampson and Burks, 1996). The most common type of food allergy is mediated by allergen-specific immunoglobulin E (IgE) antibodies. IgE-mediated reactions are known as immediate hypersensitivity reactions because symptoms occur within minutes to a few hours after ingestion of the offending food.

IgE-mediated reactions may occur to pollens, mould spores, insect venoms and other environmental stimuli as well as foods. IgE-mediated reactions affect perhaps 10-25% of the population in developed countries (Mekori, 1996), though food allergies represent a small fraction of all allergic diseases. Infants and young children are more commonly affected by IgE-mediated food allergies than adults; the prevalence among infants under the age

of 3 years may be as high as 5-8% (Bock, 1987). Food allergies are caused by a wide variety of foods. Some chemicals can alter immune responsiveness, either increasing it, leading to allergy, or depressing it. This possibility needs to be considered in the assessment of any new GM food. The insertion of genes that code for novel proteins not normally present in traditional food products may result in increased allergic reactions in some consumers. The allergenic potential of the modified food product is evaluated as part of the overall food safety assessment, particularly if either the source of the inserted genes or the host are known to cause allergy. This includes comparing the structure of the gene products with the known allergens. It is also important to consider how functional the protein gene product would be in the food as consumed (after processing and/or cooking), the level at which it might be present and the likelihood that it would resist the digestive process in the gut. Assessment of potential allergy is complicated by the lack of suitable animal models that can be used on a routine basis in safety evaluations, although research is underway to find mechanisms to identify proteins that are likely to cause an allergic reaction (Nutrition Foundation Australia, 2001).

There is concern that GM foods pose an allergy risk. Currently the list of GM food products intersects with the eight most common food allergens: eggs, milk, fish, peanuts, shellfish, soy, tree nuts and wheat. Proteins in food are what trigger most allergic reactions in people. Most of the foreign proteins being gene-spliced into foods have never been eaten by humans before or tested for their safety. Subsequent exposure of a sensitised individual to an offending food will likely elicit an allergic reaction. There are not a large number of potential allergens in the food marketplace (WHO, 2001).

Pusztai (2003) working on GM potatoes suggested that the consumption of genetically modified food might result in depression of the immune system. The mechanisms by which this could occur are unclear. The Royal Society evaluated the work and found that it was flawed in many aspects of the design, execution and analysis and so no conclusions could be drawn from it. They also concluded that it would be unjustifiable to draw any general conclusions about the safety of GM foods in general from the results of studies, however well con-

ducted, on one particular product modified by the insertion of one particular gene by one particular method (BMA, 2003). No allergic effects have been found relating to GM foods currently on the market (WHO, 2003).

In 1996 a major Genetically Engineered food disaster was narrowly averted when Nebraska researchers learned that a Brazil nut gene spliced into soybeans could induce potentially fatal allergies in people sensitive to Brazil nuts. However, animal tests of these Brazil nut-spliced soybeans had turned up negative (Cummins, 2000).

### Nutritional status

GM foods could have different effects on those of poor nutritional status and/or those belonging to "vulnerable groups" (notably the foetus, infants, children, pregnant and lactating women, the elderly and those with chronic disease) when compared with healthy individuals (BMA, 2003). Pusztai (2003) observed that genetically modified food will likely result in foods lower in quality and nutrition. For example the milk from cows injected with rBGH contains higher levels of fat (Australian Nutrition, 2001).

### The African case

In Africa, the problem of GM foods remains a topic of little discussion. Awareness is mainly among the educated population, which is minimal compared to the highly industrialised West. There is famine in many countries in Southern Africa but many governments in the region find themselves in a dilemma as they have to choose between letting their citizens starve to death or giving them genetically modified maize and other grains from the U.S.A.) (Wendo, 2001). Reacting to the concerns in Southern Africa, the UN's World Food Programme (WFP), the FAO and the WHO issued a joint statement in August 2002 stating that the consumption of GM foods presents no human health risk. Therefore, these foods may be eaten. The UN agencies affirmed, however, that each recipient country has a right to accept or reject the entry of GM foods (WHO, 2000). Although nearly 30 per cent of Zambia's 10.2 million people are facing starvation, the government of President Levy Mwanawasa has bowed to concerns about the potential hazards of genetically modified foods and has flatly refused to accept GM grain. Despite the controversy, the WFP has continued to offer GM

food aid to countries in need. The agency notes that it has been distributing GM food aid elsewhere for some time and in some Southern African countries since 1992/93, with no reports of deaths or health concerns (Wendo, 2001).

### CONCLUSION

Research on GM foods is continuing and there have been no concrete proof that GM foods are potentially hazardous health wise (BMA, 2003). Of course, like everything new people are inclined to be sceptical about these GM foods. The use of GMOs has the potential to offer real benefits in agricultural practice, food quality, nutrition and health. There are, however, uncertainties about several aspects of GMOs, GM foods and GM crops. Continued research, funded in part from public sources with the results made openly available, is essential if these uncertainties are to be properly addressed. As African biotechnologists said in a workshop in Nairobi in 2001, GM foods should be rigorously checked and accepted in their countries of production before being allowed on the African market. African countries should harmonise legislation on GM foods and set up regional clearinghouses. It is also important for Africans to get involved in the production of GM foods to address our needs, as the west will produce predominantly to satisfy its desires.

### REFERENCES

- BMA.** (2003). genetically modified foods and health: a second interim statement. British Medical Association, London, June 2003.
- Bock, S.A.** (1987). Prospective appraisal of complaints of adverse reactions to foods in children during the first three years of life. *Paediatrics*, 79: 683-688.
- Combs, G.F. Jr., Duxbury, J.M. & Wetch, R.M.** (1997). Food systems for improved health: linking agricultural production and human nutrition. *Eur. J. Clin. Nutr.* 51: S32-S33.
- Dietz, W.H.** (1998). Health consequences of obesity in youth: childhood predictors of adult disease. *Paediatrics*, 101: 518-25.
- Friedrich, M.J.** (1999). Genetically enhanced rice to help fight malnutrition. *JAMA*, 282: 1508-1509.
- Grundy, S.M.** (1981). Dietary fats and sterols. In: Kritschovsky D. (ed.). *Nutrition and killer*

diseases. Willey, New York, pp57-83.

**Hawkins, D.J. & Kirdl, J.C.** (1998): Characterization of acyl-AAACP thioesterases of mangosteen (*Garcinia mangostana*) seed and high levels of stearate production in transgenic canola. *Plant J.*, 13: 743-52.

**James, C.** (2000). Global Review of Commercialised Transgenic Crops. ISAAA. Ithaca, NY.

**Kenney A.J. & Knowlton, S.** (1998). Designer oils: the high oleic acid soybean. In: Roller S. (ed.). Genetic Modification in the food industry: A strategy for Food Quality Improvement. Aspen Publisher, Frederick, USA.

**Krause M.V. & Mahan L.K.** (1979). Food, Nutrition and Diet Therapy, 6<sup>th</sup> ed. WB Saunders Company, Philadelphia.

**Lucca, P., Wunn, J., Hurrell, R.F. & Potrykus, I.** (2000). Development of iron-rich rice and improvement of its absorption in humans by genetic engineering. *J. Plant Nutr.*, 23: 1983-1988.

**Lui, K. & Brown F.A.** (1996). Enhancing vegetable oil quality through plant breeding and genetic engineering. *Food Technology*, 50:67-71.

**Mekori, Y.A.** (1996). Introduction to allergic diseases. *Critical Reviews in Food Science and Nutrition*, 36: S1-S18.

**National Cholesterol Education program.** Report of Expert Panel on Blood cholesterol Levels in children and adolescents, USDA 1987-1988 Nationwide Food consumption survey. United States Department of Health and Human Services. NIH publication No. 91-2732: 2991

**Nutrition Australia** (2001). GM Foods and Human Nutrition. [www.nutritionaustralia.org/food\\_facts/FAQgms.asp](http://www.nutritionaustralia.org/food_facts/FAQgms.asp)

**Orf, J.H.** (1988). Modifying soybean composition by plant breeding. In: McCANN, L. (ed.). Proceedings of a symposium on Soybean Utilization Alternative, 16-18 February 1988, St. Paul, Minnesota.

**Perr, H.A.** (2002). Children and genetically engineered foods: potentials and problems. *J. Paed. Gast. Nutr.*, 35: 475-486.

**Potrykus, I.** (2001). Golden rice and beyond. *Plant Physiology*, 125: 1157-1161.

**Pusztai, A.** (2001). Genetically Modified Foods: Are They a Risk to Human/Animal Health? Health Risk. [www.actionbioscience.org/biotech/pusztai.html](http://www.actionbioscience.org/biotech/pusztai.html).

**Pusztai, A.** (2003). Contaminants and toxins. In: D'MELLO, J.P.F. (ed.). Food Safety. Scottish Agricultural College, Edinburgh, UK.

**Sampson, H.A. & Burks, A.W.** (1996). Mechanisms of food allergy. *Annual Review of Nutrition*, 16: 161-177.

**Schafer, E.J.** (2002). Lipoproteins nutrition and heart disease. *A. J. Clin. Nutr.*, 75: 192-212

**Thelen, J.J. & Ohlrogge, J.B.** (2002). Metabolic engineering of fatty acid biosynthesis in plants. *Metabolic Engineering*, 4:12-21.

**Spady, D.K., Biltheimer, D.W. & Dietschy, J.M.** (1983). Rates of receptor-dependent and-independent lipoprotein uptake in the hamster. *Proc Natl. Acad. Sci. USA*, 80: 3499-505.

**Wendo, C.** (2001): African biotechnologists debate GM foods. *The Lancet*, 358: 1970.

WHO (2000). Safety aspects of genetically modified foods of plant origin. Report of a joint FAO/WHO Expert Consultation on Foods Derived from Biotechnology, WHO, Geneva.

WHO (2001). Evaluation of Allergenicity of Genetically Modified Foods. Report of a joint FAO/WHO Expert Consultation on Allergenicity of Foods Derived from Biotechnology. World Health Organisation, Geneva, Switzerland.

**Yip, R.** (1997). The challenge of improving iron nutrition: Limitations and potentials of major intervention approaches. *Eur. J. Clin. Nutr.*, S16-S24.