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Are there health hazards for the consumer from eating genetically modified food?

Abstract
Based on the published scientific literature, this report examines the potential hazards and risks of consuming genetically modified (GM) plant products. Toxicity, carcinogenicity and food allergenicity, and the possible effects of consuming foreign DNA (including antibiotic resistance genes) are all taken into account. The report concludes that food derived from GM plants approved in the EU and the US poses no risks greater than those from "conventional" food. On the contrary, in some cases food from GM plants appears to be superior with respect to health.

Probably no discovery in plant sciences has had, in so short a time, such far reaching consequences on agriculture as the method reported in 1983 for the genetic modification of plants using gene technology. In 2005, such genetically modified varieties comprised 60% of global soy bean cultivation, 14% of maize, 28% of cotton and 18% of rape seed; between 2003 and 2005 the overall increase of the area worldwide given over to GM crops was 33%. This clearly demonstrates that the application of gene technology in agriculture has economically been very successful.

Genetic modifications in crop plants have so far focussed primarily on the production of herbicide-tolerant varieties for minimising harvest losses due to weeds, and the generation of insect-resistant varieties to decrease losses from insect damage. More recent developments are directed to protection against viral and fungal infections, the enhancement of tolerance towards drought and salinity, the formation of male sterile plants for the generation of productive hybrids, and the improvement of the nutritional quality of crop plants, for example by modifying the fatty acid composition in oil seeds.

The campaigns of opponents of agricultural biotechnology have deliberately provoked widespread public anxiety by asserting that food from genetically modified organisms (GMOs) is a health hazard. "Organic" products are advertised as free from GMOs, thus claiming that they are especially healthy. The slightest trace of GMOs in "organic" products as a result of cross-pollination is termed "genetic pollution"; in some countries it may justify a claim for damages.

Does the consumption of food from GM plants really involve a health hazard for the consumer?

The present report bases its findings on reliable and attributed data. Thus, all the information used is derived from publications in peer-reviewed scientific journals in which contributions are reviewed anonymously by experts in the field. The interests of the consumer are protected by very rigorous licensing procedures based on scientifically robust protocols as laid down by national and international organisations, including the FAO (Food and Agricultural Organisation of the United Nation), the OECD and the European Union. These regulations are much stricter than those required for conventionally grown food *which normally receive no formal testing whatsoever from a health perspective*. Moreover, in the European Union it is now obligatory that all food ingredients from GM plants are so labelled if they exceed a threshold content of 0.9% for each ingredient.

In principle, no absolute guarantee can ever be offered for the safety of any food, whether produced conventionally or from GM plants. It is common knowledge that conventionally produced food can be the cause of allergies for predisposed persons; nuts (and particularly peanuts), strawberries, shellfish and wheat are all familiar examples. Foods of plant origin often contain toxic or carcinogenic substances; nature has provided plants with a large arsenal of defensive substances as protection against damage from feeding insects or from

bacterial and fungal infections. Moreover, plant products may be contaminated by fungal toxins, a number of which are strongly carcinogenic; *Fusaria* toxins, which often pollute wheat and maize (even when grown "organically"), are examples. It has been estimated that in the industrial countries most of carcinogenic substances ingested derive from "natural" plant food.

Since absolute safety is never possible, the basis for approving GM food products is the failure – after extensive prescribed testing – to find any adverse indicators. Such tests show that these foods are at least as safe and nutritious as the corresponding products from conventionally produced crops.

This paper addresses in more detail some conceivable risks of consuming products containing GMOs or products containing them. Note has been taken in particular of the very detailed GM Science Report of the Royal Society (first report 2003, second report 2004), compiled by a panel of 28 distinguished scientists from various disciplines, a report from the Food Standard Agency (UK) and the Symposium of Green Biotechnology of the Union of the German Academies (2002).

Is it possible that some/all GM foods are more toxic or carcinogenic than conventionally grown food, either directly because of the new gene product itself or from unexpected effects of the new inserted gene(s) causing damage to one or more existing genes?

It must be stressed that conventional breeding has for long treated seeds with mutagenic chemicals or high-energy radiation (γ-rays from a cobalt radiation source) to promote random mutations in the hope that some of them may be beneficial; the potential dangers from such mutations are very much higher than those both from transgenic plants or, indeed, from the natural mutations which occur continually in all living organisms. Yet no formal testing is required of their safety as human and animal food.

The situation is very different for GM products. It takes at least ten years to develop a new GM variety, during which time a very detailed investigation is undertaken in both laboratory and field trials of the equivalence of the GM plant and its conventional counterpart: they are compared with respect to phenotype, growth and nutritional properties, and chemical composition. Toxicity and carcinogenicity are tested in feeding trials with livestock and rats before the product can be approved for the market. Trials with thousands of animals have shown GM products to be harmless; no scientifically substantiated reports have suggested that the health or productivity of animals is impaired after being fed GM fodder in comparison with the conventional equivalent. Moreover, for some ten years GM food products have been part of the human diet in the US and some other countries. It is estimated that 60-70% of the processed foods on US supermarket shelves contain GM components – and they are not labelled. There have accordingly been trillions of GM meals eaten without any scientifically-based report indicating a single health hazard; not one. Furthermore, in spite of a number attempts to do so, there has been no successful consumer claim in any court anywhere for compensation for damage supposedly incurred from the consumption of GM products. This constitutes yet more evidence for the efficacy of the testing procedures and for the safety of the products themselves.

On the other hand, the well-known health risk to consumers from the presence in maize of contaminating fungal toxins is decreased in GM insect-resistant varieties. Conventional maize cobs are often infected with the fungus *Fusarium moniliforme,* resulting in production of the fungal toxin *fumonisin*. For more than a century, "mouldy corn disease" has been recognised as a hazard for horses, pigs and other livestock, with entire herds dying after being fed corn infected with *Fusaria*. Sixteen years ago, the fumonisin was identified as the cause of the disease. It is known to induce liver cancer in rats. Fumonisin is a thus serious problem; it so stable that it survives processing and can sometimes be found in cornflakes. In the UK in September 2003 the analysis of 30 samples of maize products in supermarkets led to the removal of ten of them because of excessively high levels of fumonisin content; the contaminated samples with the highest fumonisin contents were those labelled "organic".

Several studies have found contamination with fumonisin to be greatly decreased in insect-resistant (Bt) GM maize; whereas in conventional maize plants the fungi proliferate in cobs injured by insects, in GM maize there is much less insect damage and hence less fumonisin. ***These findings indicate that food from GM maize is more healthy for humans than that from conventionally grown maize***.

Is there a higher risk of food allergy from eating food derived from GM plants than from conventional food?

Estimates suggest that 5-8% of children and of 1-2% adults are allergic to certain conventionally produced foods. Peanuts, for instance, are known to contain 12 allergenic proteins.

While there is no legal requirement for the testing of foods from conventional varieties, strict allergy tests are mandatory for GMO products. The WHO (World Health Organisation) has introduced a protocol for detailed GMO allergenicity tests, both for the plant products concerned and also for their pollen. This protocol is being constantly improved. Tests of this sort on one occasion alerted scientists to the fact that the introduction of a gene from brazil nut into soy bean, in the hope that it would improve quality, would be allergenic for certain persons. As a result, further development of that GMO was abandoned by the company involved prior to any commercialisation, demonstrating that the safety regulation system functions well.

Our collective experience to date shows the strict allergenicity tests of GM products to have been very successful: not one allergenic GM product has been introduced onto the market. In conventional breeding, in which genes are altered at random by experimentally caused mutations or unexpected gene combinations generated by crossings, such tests are not legally required. ***For this reason the risk of GM plants causing allergies can be regarded as substantially lower than that of products from conventional breeding.*** Furthermore, intensive gene technology research is already under way with a view to removing allergens from peanuts, wheat and rice.

Has the consumption of transgenic DNA adverse effects on health? Might transgenic DNA survive the digestive track and become incorporated into human cells, thus altering their genetic information? Does transgenic DNA affect the intestinal microflora and might this constitute a health risk?

Every day, people on average consume 0.1-1 g DNA daily in their food. In food from GM plants, transgenic DNA would amount to about 1/100,000 – 1/1,000,000 part of this. Scientists are in agreement that digestion of transgenic DNA in no way differs from that of DNA from conventional food. The "new" genes in GM plants derive mostly from other organisms already present in conventional food: viruses and soil bacteria are present in vegetables.

All DNA, transgenic or not, is degraded in the digestive track although this process may not always be complete. Experiments with animals have shown that very limited quantities of DNA fragments from food may be taken up into blood and body cells; it probably applies equally to humans. Nevertheless, this would have no effect on the genetic composition of human cells; the stable integration of plant DNA into animal genomes has never been observed, with natural barriers apparently in place to prevent any such horizontal gene transfer.

To provide a promoter (gene switch) for the synthesis of the foreign protein in GM plants, a promoter from the cauliflower mosaic virus (CMV) is often used. There has been speculation that the DNA sequence of this virus promoter might be incorporated from undigested plant material into the genome of human cells, there to provoke the development of tumours. No evidence has been provided for this proposition which ignores the fact that the viral promoter has the properties of a plant DNA with its uptake into the human genome prevented by the natural barriers mentioned above.

But there is another significant detail negating this speculation: for centuries, cabbage and cauliflower have been part of the human diet. Since half of all cauliflower and 10% of cabbage is infected with the virus, people have been eating cauliflower mosaic virus for centuries or perhaps for millennia. There have never been adverse health reports from the consumption of these naturally "contaminated" vegetables.

Experimental research has demonstrated that natural barriers make the horizontal gene transfer of plant DNA extremely unlikely, whether from the roots of plants into soil bacteria or from an animal digestive track into intestinal bacteria. This argues strongly against unsupported assertions that recombinant DNA from a transgenic plant might be spread by bacteria.

The situation is different in the case of recombinant DNA originally derived from a bacterial source. Those DNA sequences can indeed be inserted into bacterial genomes by homologous recombination. A number of approved GM plants do contain bacterial genes conferring resistance to antibiotics; they are used as selection markers in the procedure of gene transfer. The possibility exists of these resistance genes being transferred to intestinal bacteria. In most cases, the gene employed confers resistance to the antibiotics kanamycin and neomycin. Because of their high toxicity, these antibiotics are very seldom used in human medicine, and then exclusively for external applications only. Moreover, the resistance genes to these two antibiotics are already present in large amounts in an average soil sample.

Occasionally, bacterial ampicillin-resistance genes have been used as selection markers for the generation of GM plants. Since ampicillin is used medically for severe infections such as meningitis, there has been speculation that the consumption of products from the corresponding GM plants might lead to a loss of therapeutic effectiveness due to the spread of ampicillin resistance via intestinal bacteria. Plausible though this scenario at first sight appears to be, in normal healthy persons up to 27% of the *Escherichia coli* bacteria in the intestine *already contain this ampicillin resistance gene.* The practice of adding antibiotics to cattle fodder

means that the droppings of 75% of cattle and pigs in Germany were found to contain *Escherichia coli* bearing the ampicillin resistance gene. In New Zealand, some 20% of soil bacteria were found to contain the ampilicillin marker even though GM plants had never been grown there. ***This clearly shows that the presence of these antibiotic resistance markers in GM plants, even were they to survive passage through the digestive tract, represent no risk to human health***. However, since it seems to be impossible to convey to the general public the differentiation between various antibiotics and the corresponding resistance genes, they are no longer used as selection markers or are later excised and so not present in GM plants.
In summary, the evidence suggests it to be most unlikely that the consumption of the well-characterised transgenic DNA from approved GMO food harbours any recognisable health risk

Conclusion

This paper noted at the outset that the consumption of any foodstuff harbours various degrees of risks to health. Estimating the importance of risks specifically related to GM food products can be made only by comparison with the corresponding conventional products. The former offer the advantage of having been exceptionally thoroughly tested with respect to health risks; the latter have not been tested at all. In estimating the health risks, it is also relevant to remember that, since 1996, hundreds of millions of people in the Americas and elsewhere have regularly been consuming GM products as part of their normal diets without any proven evidence of adverse health effects. It might be argued that this is only evidence for the absence of strong and easily observed adverse effects, and that milder or long-term damage cannot be excluded. While long term effects are not expected that is equally true for all food; *how many of our ailments in later life derive from decades of eating particular food*s? For the most part, we do not know.

The present regulations for the approval of GM plants and their product has established a framework which:
1) affords an effective safety evaluation on the basis of scientific data before marketing;.
2) requires GM products to be labelled by law, so offering the consumer informed choice;
3) specifies monitoring procedures which will reveal unexpected effects after the introduction of GM products onto the market;
4) permit the regulatory authorities to evaluate these data at any time.

This report shows that, because of the rigour with which they must be tested and the controls to which they are subject, it is extremely unlikely that GMO products approved for market in the European Union and other countries present a greater health risk than the corresponding products from conventional sources.

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For the sake of brevity only a small selection of references is listed here. These references and very many others relevant to this report are contained in a collection of pertinent literature which is available at the website http://www.akademienunion.de/publikationen/literatursammlung_gentechnik/english.html

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