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

Abstract
On the basis of existing scientific literature this report examines the potential risks for people who consume products of genetically modified (GM) plants. Taken into account are toxicity, the potential of causing cancer and food allergies, and the effects of consuming foreign DNA, including the DNA of antibiotic resistance genes. The report reaches the conclusion that in consuming food derived from GM plants approved in the EU and in the USA, the risk is in no way higher than in the consumption of food from conventionally grown plants. On the contrary, in some cases food from GM plants appears to be superior in 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 by means of gene technology. Only 20 years later, genetically modified varieties were grown on 55% of the global cultivation area of the soy bean, 11% of maize, 21% of cotton and 16% of rape seed, whereby the overall increase amounted to 12% in 2002 and to even 15%. in 2003. This clearly demonstrates that in agriculture the application of gene technology has been very successful economically. So far the genetic modifications focussed primarily on the generation 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 deal with protection against viral and fungal infections, the enhancement of tolerance towards dryness and salinity, the formation of male sterile plants for the generation of productive hybrids and the improvement of the nutritional quality of crop plants, e.g. by the modification of the fatty acid composition in oil seeds.
The campaigns of opponents of Green Biotechnology, such as for instance Greenpeace, have led to great anxiety among large parts of the population, by implying that food from genetically modified organisms (GMO) is a health hazard. “Organic” products are advertised as free from GMO, suggesting that they are especially healthy. The slightest trace of GMO resulting from the distribution of pollen in “organic” cultures, is termed genetic pollution and in some countries is regarded as a reason for damage claims.

The question arises: does the consumption of food from GM plants really involve a health hazard for the consumer?

The present report will answer this from the scientific viewpoint. This means that all the information is ultimately derived from publications in peer reviewed scientific journals, where the contributions are checked according to scientific criteria.
The interests of the consumer are protected by very rigid licensing procedures with scientifically robust protocols laid down by national and also international organisations, such as for instance 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. Moreover, in the European Union it is now obligatory that all ingredients from GM plants in food are labelled as such.
In principle, an absolute safety of food, whether produced conventionally or from GM plants, cannot be guaranteed. It is common knowledge that conventionally produced food can be the cause of allergies for predisposed persons. Food of plant origin can also contain toxic or carcinogenic substances. Nature has provided plants with a large arsenal of defence substances as a 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. The Fusaria toxins, which often pollute wheat and maize also when grown “organically”, may serve here as an example. It has been estimated that in the Western civilisation the majority of ingested carcinogenic substances derive from natural plant food.
Since absolute safety is not possible, the basis for the approval of food products containing GMO is the evidence that they are at least as safe and nutritious as the corresponding products from conventionally produced crops.
The following deals in more detail with the widespread discussion on the possible risks from consuming products containing GMO. The basis for this will be, amongst others, 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 due to the new or varied gene products in GMO, food containing GMO has a higher toxicity or cancerogenicity than conventionally grown food, deriving either from the effect of the new gene product, or by unexpected mutations from the insertion of the new gene (insertion mutant), causing damage to an existing gene?

First let it be stressed that in the process of conventional breeding utilising mutagenic chemicals or energy rich radiation (e.g. γ rays from a cobalt radiation source), the dangers due to unintentional mutations are very much higher than in the generation of transgenic plants. For the development of a GMO variety the time normally required is at least 10 years, during which a very detailed investigation of the equivalence of a GM plant in respect to the phenotype, growth properties and their content of substances is undertaken in laboratory and field trials. Toxicity and carcinogenicity are tested in feeding trials with livestock and rats before approving this product for the market. Feeding trials with thousands of animals has proved GMO products harmless, and there has been no scientifically founded report that the health or productivity of animals was impaired after being fed GMO fodder as compared to conventional fodder. It may be noted that for about 7 years in the USA and some other countries products from GM crops have been part of the daily food. According to an estimation 60-70% of the processed food on supermarket shelves in the USA contains GMO components. There has been no scientifically founded report, which prognosticated a hazard to health, and not a single one that people had had health problems after consuming GMO food. The fact that there has been no successful consumer court claim in respect to the consumption of GMO products may be regarded as further evidence for the validity of this statement.
On the other hand, there are reports that in the case of maize the consumer health risk in respect to contaminating fungal toxins is decreased when eating food from GMO varieties. Frequently maize cobs are infected with the fungus *Fusarium moniliforme,* resulting in contamination with the fungal toxin Fumomisin. For more than a century the “moldy corn disease” is known to be a hazard for horses, pigs and other livestock, and entire herds have died after being fed corn infected by Fusaria. Sixteen years ago the toxin Fumonisin was identified as the cause of the disease. Fumonisin was found to induce cancer of the liver in rats. Fumonisin is so stable that it can still be found in Cornflakes. It constitutes a serious problem. In the UK in September 2003 the analysis of 30 samples of maize products in supermarkets led to the removal of 10 products because of too high Fumonisin contents. It may be noted that the samples with the highest Fumonisin contents were labelled “organic”. Several investigations have demonstrated that the contamination with Fumonisin is largely decreased in insect-resistant (Bt) GM maize . This is because the Fusaria fungi proliferate where the cobs have been injured by insects, but in GM maize there is much less feeding damage. ***These findings indicate that food from GM maize is more healthy than that from conventionally grown maize.***

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

It has been estimated that 5-8% of children and of 1-2% adults are allergic to certain conventionally produced food. Peanuts are known to contain 12 allergenic proteins. Whereas for conventional varieties there is no legal requirement for allergy tests of their products, for GMO products very strict allergy tests are mandatory. The WHO (World Health Organisation) has introduced a protocol for detailed tests of allergenicity for GMO, for the plant products concerned, and also for their pollen. This protocol is being constantly improved. Such tests, for instance, brought to notice that the introduction of a gene from brazil nut into soy bean, where it was hoped to improve the quality, was allergenic for certain persons. As a consequence the further development of this GMO was stopped by the company prior to any commercialisation, demonstrating that the system of safety regulation functions well. On the whole the strict allergenicity tests of GMO have been very successful, and until now no single allergenic GMO has been introduced to the market. In the case of conventional breeding, where genes are altered at random by experimentally caused mutations, or unexpected gene combinations are 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.*** In addition, gene technology offers in the long term the possibility to remove allergens from e.g. peanut, wheat and rice. At present intensive research is being carried out on this project .

Has the consumption of transgenic DNA adverse effects on health? Could it be that transgenic DNA survives its passage through the digestive track and is incorporated into

human cells thus altering their genetic information? Does the transgenic DNA affect the microflora of the intestine and could this constitute a health risk?

The average person consumes daily with his food between 0.1-1 g DNA. When eating food derived from GM plants, transgenic DNA would amount to about 1/100 000 –1/1000 000 of this. Scientists are in agreement that digestion of transgenic DNA differs in no way from that of DNA in conventional food. In the end the "new genes" in GM plants derive mostly from other organisms contained in conventional food, e.g. the viruses and soil bacteria occurring in vegetables. All DNA, including transgenic DNA, is degraded in the digestive track, although this process may not always be complete. Experiments with animals showed that in very limited cases DNA fragments from the food may be taken up into the blood and body cells. This probably also applies to humans. This very rare uptake, however, has no effect on the genetic outfit of the cells, as a stable integration of plant DNA in animal genomes has never been observed. Apparently natural barriers exist for such a horizontal gene transfer. In GM plants, as gene switch (promoter) for the synthesis of the foreign protein often a promoter from the cauliflower mosaic virus (CMV) is used. There has been speculation that the DNA sequence representing this virus promoter could be taken up from undigested plant material into the genome of human cells and may cause tumours there. This speculation is invalid as the viral promoter has the properties of a plant DNA and therefore its uptake into the human genome is prevented by natural barriers as discussed above. But there is another significant detail which negates this speculation: For centuries cabbage and cauliflower have been on the human menu, and since 50% of the cauliflower and 10% of the cabbage are infected by the virus, people have inevitably always consumed large quantities of the cauliflower mosaic virus. There have been no adverse health reports on the consumption of these naturally contaminated vegetables.

Experimental research has demonstrated that natural barriers make it extremely unlikely that there is a horizontal gene transfer of plant DNA, e.g. from the roots of plants into soil bacteria or from the digestive track into intestinal bacteria . This contradicts speculations that recombinant DNA of a transgenic plant could be spread through the environment via bacteria. This does not apply, however, in the case that the recombinant DNA of a transgenic plant originally derived from bacteria. Such DNA sequences can be inserted into bacterial genomes by homologous recombination. A number of approved GM plants contain bacterial resistance genes against antibiotics as a selection marker, and the possibility exists that these resistance genes could be transferred to intestinal bacteria. In most cases a resistance gene is used against the antibiotics Kanamycin and Neomycin . Both antibiotics, because of their high toxicity, are very seldom used in human medicine and then exclusively for outer applications only. Moreover, the resistance genes to these two antibiotics occur in large amounts in any average soil sample. In rarer cases, however, bacterial Ampicillin resistance genes have been used as selection markers for the generation of GM plants. Since Ampicillin is used as one of the antibiotics for severe infections, e.g. meningitis of the brain, it has been speculated that the consumption of products from the corresponding GM plants could lead to its ineffectiveness, due to the spread of Ampicillin resistance via intestinal bacteria . This scenario can be disproved, however, by the fact that in healthy persons already up to 27% of *Escheria coli* bacteria in the intestine contain this Ampicillin resistance gene. Due to adding antibiotics to fodder the droppings of 75%of cattle and pigs in Germany were found to contain *Escheria coli* with the Ampicillin resistance gene. ***This shows clearly that the presence of the above mentioned antibiotic resistance markers in GM plants, even in the rare case that they survive the passage through the digestive track, represent no risk to human health***. Since it seems to be impossible to convey to the general public the differentiation between various antibiotics and the corresponding resistance genes, antibiotic resistance genes are no longer used as selection markers or are excised afterwards, and are thus no longer contained in novel GM plants.

In summary, it can be stated that according to present scientific knowledge it is most unlikely that the consumption of the well characterised transgenic DNA from approved GMO food harbours any recognisable health risk

Conclusion

As mentioned at the beginning, the consumption of any food stuff harbours various degrees of risks to health. The estimation of risks upon the consumption of GMO food products can only be made in comparison with the corresponding conventional products. GMO products offer the advantage that they have been exceptionally thoroughly tested in respect to health risks. It is also relevant in estimating the health risk that since 1996, especially in the New World, hundreds of millions of people have consumed GMO products as part of their diet, without any scientifically proven reports of adverse health effects. It may be argued that this is only evidence for the absence of strong and easily observed adverse effects, and that milder damage occurring only after longer terms cannot be excluded. According to our present knowledge, however, such long term effects are not to be expected. The present regulations for the approval of products from GM plants established a framework of prerequisites which

1) enable an effective safety evaluation on the basis of scientific data before introduction to the market.
2) by laws requiring that GMO products are labelled and thus the consumer is given a choice.

3) by monitoring procedures which enable the observation of unexpected effects after the introduction of GMO products to the market.
4) which enable the regulatory authorities to evaluate these data also after the introduction of GMO products.

After considering the arguments of this report it appears extremely unlikely that the consumption of GMO products approved to market in the European Union and other countries harbours a higher health risk than the consumption of conventional products. On the contrary, GMO products have been tested to a particularly high extent and are subjected to rigid legislation control.

References

GM Science Review: An open Review of the science relevant to GM crops and food based on the interest and concern of the public. The Royal Society (London) First Report Juli 2003, Second Report Januar 2004
Grüne Gentechnik. Akademie Journal 1/2002, S. 1-46
Global Status of Commercialised Transgenic Crops: 2003, International Service for the Acquisition of Agri-Biotech Applications No 30/2003
Food Standards Agency (UK) Report Sept. 2003
Minorsky, P.V. Fumonisin Mycotoxins. Plant Physiol. 129, 929 (2002)

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