

GM CROPS – IS THERE A FOOD SAFETY ISSUE?

Gijs A. Kleter and Harry A. Kuiper from the National Institute for Quality Control of Agricultural Products (RIKILT) in Wageningen in the Netherlands discuss a controversial issue

Introduction

Over the last few years, genetically modified (GM) crops have rapidly gained adoption by farmers, especially in the USA, Argentina, and Canada. In 2000, the fifth consecutive year of widespread commercial cultivation of GM crops, they covered a total of 44 millions hectares of arable land. Major GM crops are herbicide-tolerant soybean, insect-resistant maize, herbicide-tolerant canola and insect-resistant cotton (James, 2000). In the EU, cultivation of GM crops is still very limited, but food and animal feed in the EU may contain GM ingredients due to the import of agricultural commodities from overseas.

Because genetic modification of food crops is a relatively new technology, there have been concerns over its impact on the environment and safety for consumers.

As explained below, before a GM crop is brought to the market as a food, it will undergo a regulatory procedure, which includes an evaluation of its food safety. The various aspects of the food safety evaluation of GM crops are also reviewed by a recent report (Custers, 2001).

Food safety evaluation of GM crops

Several years before commercial GM crops were brought to the market, activities were organised by international organisations to gather experts and to formulate safety requirements for these foods. Major organisers were the Organisation for Economic Co-operation and Development (OECD), the United Nations' Food and Agriculture Organisation and World Health Organisation (FAO/WHO), the International Life Sciences Institute (ILSI), and the International Food Biotechnology Council (IFBC).

The main issues that are addressed in the safety assessment of GM foods are:

- Molecular characterisation
- Changes in agronomical characteristics, morphology, and food composition
- Toxicity of newly inserted proteins and of the whole food
- Allergenicity
- Gene transfer
- Changed patterns in pesticide residues

The choice of tests is not random, but follows a stepwise case-by-case approach (Figure 1; Table 1).

The assessment is done in a comparative way, *i.e.* by comparing the properties of the new crop with those of the conventionally bred crop, from which the new crop has been derived. This is the so-called "substantial equivalence"

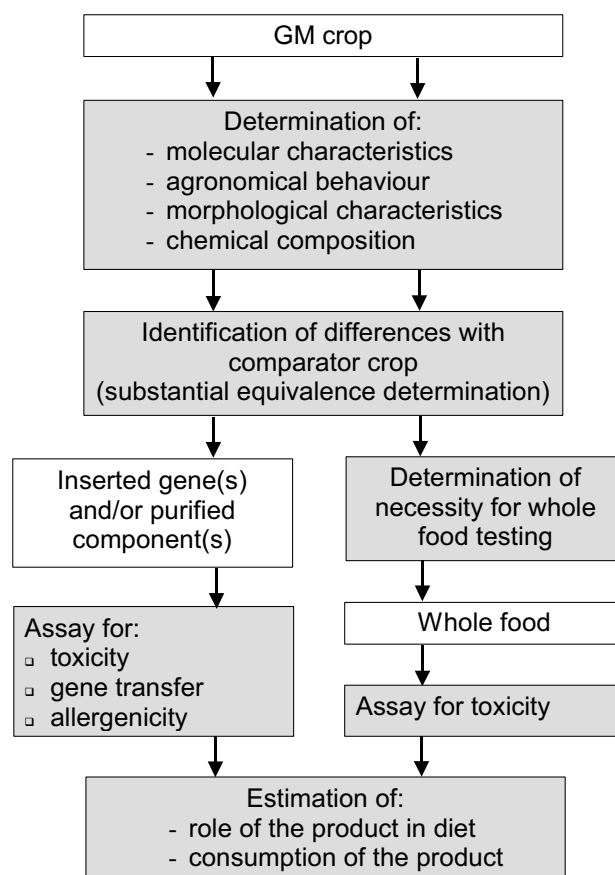


Figure 1. Food safety assessment of GM crops

Table 1. Safety items at different organisational levels of the GM crop.

Level	Issue
Novel gene	Gene transfer
Novel protein	Toxicity (animal tests) Allergenicity
Novel food/food ingredient	Substantial equivalence Toxicity (animal tests) Unintended effects Changed patterns in pesticide residues

approach. This principle was formulated by the OECD in 1993 and has since then been further developed by OECD and FAO/WHO. It presumes that traditional food can be considered as safe through its history of use (Kuiper *et al.*, 2001).

To determine substantial equivalence, the GM crop and its counterpart are compared for composition and other characteristics including phenotype (*i.e.* appearance, growth, *etc.*). Composition includes macronutrients (*e.g.* fibre, protein, fat), micronutrients (vitamins, minerals), antinutrients, and toxins. The OECD is currently preparing "consensus documents" with recommendations on which analytes should be measured for each crop. Documents have been completed for soybean and canola, while those for sugar beet, potato, maize, wheat, rice, cotton, and sunflower are being prepared (OECD, 2001).

Substantial equivalence is sometimes mistaken for a safety assessment in itself (Millstone *et al.*, 1999). It is, however, a starting point for the safety evaluation rather than an end point. It identifies differences, but does not assess them. Identified differences are further assessed with respect to toxicological implications, and further safety tests may be indicated. A GM crop containing a novel insecticidal protein, for example, could be substantially equivalent except for this new protein. In that case, further safety testing will focus on this insecticidal protein.

Toxicity

Toxicity of newly introduced proteins and, if necessary, of whole GM crops is tested in feeding experiments ("oral toxicity") with experimental animals. Commonly tested are, for example, the acute oral toxicity and the subchronic oral toxicity of pure novel proteins. For acute oral toxicity tests, proteins are supplied in one high dose into the stomach of the experimental animal. In the period (2 weeks) after dosage, animals are monitored for adverse reactions and mortality. For subchronic oral toxicity tests, animals are continuously fed the protein as part of their diet during 28–90 days, and monitored for adverse effects during the experiment and on autopsy. In addition, the possible resemblance of the new protein's structure with the structure of any known toxin can be checked with the aid of computers. Further insight into the potentially toxic properties is provided by *in vitro* studies, including testing the new protein for enzymatic activities and for its degradation under conditions simulating digestion and food processing.

In contrast to pure proteins, whole novel foods cannot be applied in high doses to animals because of nutritional imbalance and unpalatability. The dose levels of whole foods (non-GM and GM) are therefore restricted in order to avoid such adverse effects and therefore information on safety limits for the GM food is limited. If results of toxicity testing of the newly inserted proteins indicate toxic effects and the composition analysis indicates changes in the composition of the new food, feeding studies with the whole food are recommended for food items that are relevant to the human diet.

A popular test animal for continuously feeding GM crops is the broiler chicken, which grows to its full size within just

six weeks. Any nutritional imbalance is likely to be detected within these animals. Subchronic (90 days) continuous feeding tests on laboratory rodents were recently recommended by a group of experts to the FAO/WHO (FAO/WHO, 2000).

One example of an experiment in which a whole GM food was administered to test animals has been described by Noteborn *et al.* (1995). Rats were administered paste from tomatoes that had been genetically modified with a protein from the soil bacterium *Bacillus thuringiensis* that was toxic towards caterpillars that damage tomato fruits. The amount of tomatoes that these rats received daily was comparable to 13 kg of human consumption. Higher doses would have been unattainable, due to the toxicity of potassium from the tomatoes. Feeding lasted 90 days. During the experiment, body weights and feed consumption of the animals were recorded. After the experiment, tissues of the animals were examined by microscopy. No adverse effects of the Bt tomatoes compared to conventional tomatoes were found.

Gene transfer

Gene transfer is the potential release of the novel gene from the GM crop during digestion (after consumption) followed by its uptake and functional incorporation by intestinal micro-organisms. This is especially a concern for the "antibiotic resistance genes". These genes are commonly introduced into GM plants together with the gene of interest. The purpose of antibiotic resistance genes is to facilitate the recovery of GM DNA or GM plants, but these genes do not have any further purpose in the GM plant. In theory, transfer of an antibiotic resistance gene to disease-causing microorganisms in humans may render these microorganisms resistant to antibiotic therapy. This possibility is taken into consideration in the safety evaluation of GM crops (FAO/WHO, 1996; FAO/WHO, 2000). The most widely used antibiotic resistance gene is *nptII*, which codes for resistance against the antibiotic kanamycin. The *nptII* gene has been considered safe, given the low relevance of kanamycin for clinical therapy, the high natural background level of kanamycin resistance among microorganisms, and the very small chance for gene transfer in the intestines to occur (FAO/WHO, 2000).

Recently at an FAO/WHO expert consultation, however, it was recommended to apply alternatives to antibiotic resistance genes in GM crops (FAO/WHO, 2000). In addition, recent EU legislation on the environmental release of GM crops prohibits antibiotic resistance genes. Previously approved GM crops with such genes will therefore be phased out (Directive 2001/18).

Allergenicity

Potential allergenicity is a concern that affects especially the novel proteins introduced into GM crops, because all known food allergens are proteins. The latter, however, does not imply that any protein would necessarily become an allergen. An internationally acknowledged decision tree was put forward for testing GM foods for their potential allergenicity by ILSI/IFBC (Metcalf *et al.*, 1996). This decision tree was recently updated by the FAO/WHO (FAO/WHO, 2001b). The route that will be followed through this

decision tree, *i.e.* the tests that are to be done, depends on what is known about the allergenicity of the gene source.

Testing will always include comparisons by computer of the novel protein's structure with the structures of known allergens. Depending on the gene source and the outcome of the structure comparison, further testing may include:

- Reactions with antisera of patients who are allergic to either the gene source or allergens broadly related to the gene source, because allergy is an immune reaction to an allergen.
- Simulated digestion of the novel protein in the stomach. Most food allergens are stable to digestion, hence resistance towards digestion would increase the likelihood for a protein to become an allergen.
- Animal models, such as the Brown Norway rat, which is IgE-hyper-responsive. IgE is the antibody involved with allergic reactions. These animal models are useful but still need further validation (FAO/WHO, 2001b).

Pesticide residues

Changed patterns in pesticide residues are expected to occur in GM crops that either have been rendered resistant to herbicides or have incorporated pesticidal compounds as a result of the genetic modification.

In the case of herbicide-resistant crops, one would expect both an increase in herbicide residues and a different pattern of residues due to metabolism of the herbicide by the plant crop. It should be borne in mind, though, that the same herbicide may also be used to "desiccate" or "defoliate" conventional, herbicide-sensitive varieties of some crops shortly before harvest. This is a common application for the herbicides glyphosate and glufosinate, to which some commercial GM crops have been rendered resistant. In addition, processing of the harvest into food products may diminish herbicide residue levels due to, for example, extractions and increased temperatures.

Examples of GM crops producing insecticidal proteins are "Bt maize" and "Bt cotton". These crops produce insecticidal Cry-proteins, which are produced in nature by the soil bacterium *Bacillus thuringiensis*. Insecticide usage on these GM crops has been reported to decrease.

Issues pertaining to the toxicity of residues of pesticides applied to crops are commonly addressed in the regulatory approval process for pesticides.

Post-market surveillance

A new development is the requirement by new and proposed EU legislation for "post market surveillance" (PMS) of GMOs. This will put the task on the manufacturer of a GMO to compile a monitoring program, which has to be submitted with the application dossier. Currently, research is carried out by the British Food Standards Agency to determine the feasibility of PMS by monitoring consumption data and public health data. In addition, a recent proposal for an EU regulation demands a documentary system for GM products to ensure their traceability throughout the food production chain.

It can be envisioned that some future GM foods will carry a high added value and will be marketed through identity-preserved channels, such as vitamin-enriched crops. For

these GM crops it will probably be easier to cope with the proposed requirements for PMS and traceability than for the bulk GM ingredients that are currently marketed.

Detection of unintended effects

The unintended effects of genetic modification are those changes in composition, phenotype, *etc.* that were not the purpose of the genetic modification but that nevertheless occur. This may be due, for example, to the insertion of the new gene into an existing gene, whose function will be disrupted by the insertion.

Such unintended effects may be predictable or unpredictable. Prediction of unintended effects is possible if either an inserted new gene or a native gene that has been disrupted by insertion of foreign DNA interacts with a known metabolic pathway of the host plant. No prediction is possible, of course, for those effects that are (still) beyond our knowledge.

Two different approaches can be applied for the identification of unintended effects on the GM crop's composition, *i.e.* the targeted and the non-targeted approach. In the targeted approach, specific single compounds of the GM crop are analysed, and changes recorded. Unless unwanted effects can be predicted, such effects will be found by chance. Furthermore, the availability of detection methods for (unknown) toxins, for example, is a limiting factor. In the non-targeted approach, profiles (fingerprints) are established of whole extracts of the GM plant and its non-GM comparator. Differences between the profiles of GM *versus* non-GM are then further checked into, and the cause of the differences identified. Analytical methods for this non-targeted approach are:

- Functional genomics using "microarrays", microscopy slides containing thousands of microscopic probes that bind to a specific gene expression product within an extract of the GM crop (Van Hal *et al.*, 2000). This way, it was determined which genes were active during different stages of fruit ripening of tomato. This will be extended to the analysis of gene activity in GM tomatoes.
- Proteomics with the aid of separation and/or detection of proteins in extracts. A frequently used technique is two-dimensional gel electrophoresis, followed by mass spectrometry of gel spots containing separated proteins for identification. Another technique exploits the binding of proteins to chemical materials and biochemical molecules that have been attached as arrays to a microscopic "biochip". Proteins binding to the arrays can subsequently be characterised by mass spectrometry (Srinivas *et al.*, 2001).
- Metabolomics, including metabolite analysis of whole extracts by either gas chromatography (GC) coupled to mass spectrometry (MS) or liquid chromatography (LC) coupled to nuclear magnetic resonance (NMR). Using NMR to analyse tomato extracts, Noteborn *et al.* (2000) found that long-ripening GM tomatoes contained altered levels of citric acid and glutamic acid compared to conventional tomatoes.

A summary of the different methods employed at the

Table 2. Strategies for detecting (un)intended effects.

Level	Approach	
	Targeted	Non-targeted
DNA (e.g. genes)	Southern blotting sequence around new DNA	
mRNA	Northern blotting	cDNA profile (microarray)
Protein	Western blotting	protein profile (electrophoresis; microarrays)
Metabolites	specific compounds	metabolite profile (GC, LC, NMR, MS, GC-MS, LC-MS, LC-NMR)

different levels of cellular organisation is given in Table 2.

Regulation of GM crops as food

The use of GM crops for either food or animal feed requires separate permissions for each application. To obtain permission, a manufacturer of a GMO will submit a dossier containing data on the characteristics and safety of the GM crop to the authorities. The procedure for an application for a GM crop as animal feed falls under EU Directive 2001/18, while that for a GM crop as food falls under EU Regulation 258/97 (EU, 2001). Please note that for substantially equivalent GM foods, a short-cut procedure called “notification” exists. A recently proposed new regulation of the European Commission, however, would abolish this notification procedure.

Although legislation in non-EU nations may differ from that in the EU, the general principles underlying dossier evaluations are the same, as discussed above. Noteworthy in this respect is the efforts of the FAO/WHO Codex Alimentarius to develop standards and guidelines for GM foods. Standards developed by the Codex are to be incorporated into the legislation of member states and will be called upon by the World Trade Organisation for relevant trade disputes.

The items currently included by Codex in its efforts are safety assessment, risk analysis, and detection and traceability of GM foods (FAO/WHO, 2001a).

Future prospects

The GM crops that are currently in the market have been modified with one or two genes and were developed about ten years ago. Since then, novel methods for the introduction of multiple genes have been developed. In addition, experimental crops have been developed in which either metabolic pathways have been altered or new pathways have been introduced (Table 3). This development will likely deliver near-commercial GM crops in the future with more intricate genetic or metabolic alterations (reviewed by Kleter *et al.*, 2000). These future crops with multiple genes and/or profoundly altered metabolic pathways are more likely to be subject to unintended effects caused by the modifications. As noted above, the targeted compositional analysis that is currently performed on GM crops to establish their substantial equivalence may reveal such unintended changes only by chance. Novel methods to detect such effects can therefore contribute to the safety evaluation of these future GM crops.

Table 3. Experimental GM crops with altered metabolites.

Crop	Trait	Transgene	Reference
Canola	increased vitamin E	γ -tocopherol methyl transferase (<i>Arabidopsis</i>)	Shintani and Della Penna, 1998
Coffee	caffeine-free	antisense xanthosine-N-7-methyl transferase (coffee)	Stiles <i>et al.</i> , 1998
Rice	provitamin A introduced in kernels	phytoene synthase (daffodil) phytoene desaturase (<i>Erwinia</i>) lycopene cyclase (daffodil)	Ye <i>et al.</i> , 2000
Rice	iron increased in kernels	ferritin (<i>Phaseolus</i>) metallothionein (rice) phytase (mutant, <i>Aspergillus</i>)	Lucca <i>et al.</i> , 2001
Rice	iron binding compound increased secreted by plant roots	nicotianamine aminotransferase (barley)	Takahashi <i>et al.</i> , 2001
Tomato	provitamin A and lycopene increased in fruits	lycopene cyclase (<i>Arabidopsis</i>)	Rosati <i>et al.</i> , 2000
Tomato	provitamin A increased in fruits	phytoene desaturase	Romer <i>et al.</i> , 2000
Tomato	flavonoids increased in fruits	chalcone isomerase (<i>Petunia</i>)	Muir <i>et al.</i> , 2001

Apart from GM crops with agronomic benefits, crops with benefits to consumers are envisioned. The “golden rice”, for example, has been engineered with three genes, such that its kernels contain beta-carotene (provitamin A), which is uncommon to conventional rice. Another example is iron-fortified rice developed by the same group of scientists, containing three newly introduced genes to increase iron storage in the rice kernels and the intestinal uptake of iron from the rice kernels after consumption. For some future crops, both the negative and positive health impacts of a given modification should therefore be taken into account. The safety testing of new GM crops will thus pose new demands on both researchers and regulatory professionals.

Four EU-funded research projects in the fifth framework programme for research and technology development involve 35 participant laboratories and have been initiated in order to cope with these new demands. These projects aim at developing sophisticated toxicity test methods, new profiling methods, and detection methods for GM organisms. These methods are of particular interest for the new generation of GM crops. The four EU projects are clustered within the thematic network ENTRANSFOOD, whose aim is to promote exchange of information between scientists from different projects, to disseminate scientific results, and to provide a platform for discussions with stakeholders. For more information visit the website <http://www.entransfood.com>

Conclusions

As discussed above, the GM crops that are currently in the market have been modified with one or two genes. The food safety evaluation of these crops along the principles of “substantial equivalence” has worked well. The generation of GM crops now in the market can be considered as safe as traditional crops.

Future GM crops with more profound alterations are envisioned. This will have its implications on how to determine “substantial equivalence” of GM crops. Profiling methods to measure gene expression, protein profiles, and metabolite composition are appropriate for this task. Such profiling methods are currently being developed for application in this field, among others in the framework of four EU research projects clustered within the ENTRANSFOOD network (<http://www.entransfood.com>).

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References

- Custers, R. (Ed.) (2001) Safety of Genetically Engineered Crops. Flanders Interuniversity Institute for Biotechnology, Zwijnaarde. <http://www.vib.be/downloads/bioveiligheidseducatie/report.pdf>
- EU (2001) Questions and Answers on the Regulation of GMOs in the EU, MEMO/00/277 Revised. European Union, Brussels.

- http://europa.eu.int/comm/dgs/health_consumer/library/press/press208_en.pdf
- FAO/WHO (1996) Biotechnology and Food Safety. Report of a Joint FAO/WHO Consultation, Rome, Italy, 30 September – 4 October 1996. FAO Food and Nutrition Paper 61. Food and Agriculture Organisation of the United Nations, Rome. <http://www.fao.org/es/esn/gm/biotech-e.htm>
- FAO/WHO (2000) Safety Aspects of Genetically Modified Foods of Plant Origin. Report of a Joint FAO/WHO Expert Consultation on Foods Derived from Biotechnology, Geneva, Switzerland, 29 May - 2 June 2000. Food and Agriculture Organisation of the United Nations, Rome. <http://www.fao.org/es/esn/gm/biotech-e.htm>
- FAO/WHO (2001a) Joint FAO/WHO Food Standards Programme, Codex Ad Hoc Task Force on Foods Derived from Biotechnology, Second Session, Chiba, Japan, 25–29 March, 2001. Codex Alimentarius Commission, Food and Agriculture Organisation of the United Nations, Rome. <ftp://ftp.fao.org/codex/alinorm01/al0134ae.pdf>
- FAO/WHO (2001b) Allergenicity of Genetically Modified Foods. Report of a Joint FAO/WHO Expert Consultation on Foods Derived from Biotechnology. Rome, 22–25 January 2001. Food and Agriculture Organisation of the United Nations, Rome. <http://www.fao.org/es/esn/gm/biotech-e.htm>
- James, C. (2000) Global Status of Commercialized Transgenic Crops: 2000. International Service for the Acquisition of Agri-biotech Applications, Ithaca. http://www.isaaa.org/publications/briefs/Brief_21.htm
- Kleter, G. A.; Noordam, M. Y.; Kok, E. J.; Kuiper, H. A. (2000) New Developments in Crop Plant Biotechnology and their Possible Implications for Food Product Safety. National Institute for Quality Control of Agricultural Products, Wageningen. <http://www.rikilt.wageningen-ur.nl/News/biotechnology.html>
- Kuiper, H. A.; Kleter, G. A.; Noteborn, H. P. J. M.; Kok, E. J. (2001) Assessment of the food safety issues related to genetically modified foods. *The Plant Journal* 27, 503–528. <http://www.blackwell-science.com/products/journals/plantGM/tpj1119.pdf>
- Lucca, P.; Hurrell, R.; Potrykus, I. (2001) Genetic engineering approaches to improve the bioavailability and the level of iron in rice grains. *Theoretical and Applied Genetics* 102, 392–397.
- Metcalfe, D. D.; Astwood, J. D.; Townsend, R.; Sampson, H. A.; Taylor, S. L.; Fuchs R. L. (1996) Assessment of the allergenic potential of foods derived from genetically engineered crop plants. *Critical Reviews in Food Science and Nutrition* 36 (Supp), S165–S186.
- Millstone, E.; Brunner, E.; Mayer, S. (1999) Beyond ‘substantial equivalence’. *Nature* 401, 525–526.
- Muir, S. R.; Collins, G. J.; Robinson, S.; Hughes, S.; Bovy, A.; Ric De Vos, C. H.; Van Tunen, A. J.; Verhoeven, M. E. (2001) Over-expression of petunia chalcone isomerase in tomato results in fruit containing increased levels of flavonols. *Nature Biotechnology* 19, 470–474.
- Noteborn, H. P. J. M.; Bienenmann-Ploum, M. E.; Van den Berg, J. H. J.; Alink, G. M.; Zolla, L.; Reynaerts, A.; Pensa, M.; Kuiper, H. A. (1995) Safety assessment of the *Bacillus thuringiensis* insecticidal crystal protein CRYIA(b) expressed in transgenic tomatoes. In: Genetically Modified Foods - Safety Aspects, ACS Symposium Series 605 (Engel, K.-H., Takeoka, G. R. and Teranishi, R., eds.), pp. 134–147. American Chemical Society, Washington DC.
- Noteborn, H. P. J. M.; Lommen, A.; Van der Jagt, R. C.; Weseman, J. M. (2000) Chemical fingerprinting for the evaluation of unintended secondary metabolic changes in transgenic food crops. *Journal of Biotechnology* 77, 103–114.
- OECD (2001) Harmonisation of Regulatory Oversight in Biotechnology: Consensus Documents. Organisation for Economic Co-operation and Development, Paris. <http://www.oecd.org/oece/pages/home/displaygeneral/0,3380,EN-document-530-nodirectorate-no-27-9461-32,FF.html>
- Romer, S.; Fraser, P. D.; Kiano, J. W.; Shipton, C. A.; Misawa, N.; Schuch, W.; Bramley, P. M. (2000) Elevation of the provitamin A

- content of transgenic tomato plants. *Nature Biotechnology* 18, 666–669.
- Rosati, C.; Aquilani, R.; Dharmapuri, S.; Pallara, P.; Marusic, C.; Tavazza, R.; Bouvier, F.; Camara, B.; Giuliano, G. (2000) Metabolic engineering of beta-carotene and lycopene content in tomato fruit. *The Plant Journal* 24, 413–419.
- Shintani, D.; Della Penna, D. (1998) Elevating the vitamin E content of plants through metabolic engineering. *Science* 282, 2098–2100.
- Srinivas, P. R.; Srivastava, S.; Hanash, S.; Wright, G. L., Jr. (2001) Proteomics in early detection of cancer. *Clinical Chemistry* 47, 1901–1911.
- Stiles, J.; Moisyadi, I.; Neupane, K. R. (1998) Purified proteins, recombinant DNA sequences and processes for producing caffeine free beverages. WO Patent 9842848.
- Takahashi, M.; Nakanishi, H.; Kawasaki, S.; Nishizawa, N. K.; Mori, S. (2001) Enhanced tolerance of rice to low iron availability in alkaline soils using barley nicotianamine aminotransferase genes. *Nature Biotechnology* 19, 466–469.
- Van Hal, N. L. W.; Vorst, O.; Van Houwelingen, A. M. M. L.; Kok, E. J.; Peijnenburg, A.; Aharoni, A.; Van Tunen, A. J.; Keijer, J. (2000) The application of DNA microarrays in gene expression analysis. *Journal of Biotechnology* 78, 271–280.
- Ye, X.; Al Babili, S.; Klöti, A.; Zhang, J.; Lucca, P.; Beyer, P.; Potrykus, I. (2000) Engineering the provitamin A (β -carotene) biosynthetic pathway into (carotenoid-free) rice endosperm. *Science* 287, 303–305.

Dr.ir. Gijs Kleter is a scientist at the Dutch National Institute for Quality Control of Agricultural Products (RIKILT), which specialises in food safety issues. Dr Kleter takes part in the safety assessment by the Dutch authorities of safety data provided by companies that intend to market genetically modified organisms.

Dr. Kuiper (RIKILT) is involved in safety assessment of residues of agrochemicals in food, of health protecting compounds and of genetically modified foods. He is a leader of various national and EU-financed projects concerning food safety, and co-ordinator of the European Network on Safety of Transgenic Foods (ENTRANS-FOOD) funded by the European Commission. He is a member of various advisory committees on biotechnology, such as the EU Scientific Committee on Plants. Furthermore he has chaired and participated in international expert conferences on genetically modified foods.

For further information contact: G. A. Kleter, RIKILT, P. O. Box 230, NL 6700 AE Wageningen, Netherlands (Fax: +31 (0) 317 41 77 17 email: g.a.kleter@rikilt.wag-ur.nl).

GM CROPS AND FOOD

Royal Society gives qualified all-clear to GM food

A Royal Society report, published on 4 February 2002, concludes that GM foods pose a “negligible risk to human health”, but also points out that there should be tighter regulations to reassure customers, particularly with respect to allergy testing. The report recommends that the principle of ‘substantial equivalence’, whereby a new GM food is deemed safe if it is essentially the same as the unmodified equivalent, should be made more explicit and objective during safety assessments, and harmonised between Member States of the European Union. For further information contact press@royalsoc.ac.uk

Bt corn and monarch butterflies

A consortium of federal, university and industry scientists led by the Agricultural Research Service of the U.S. Department of Agriculture has completed two years of research to answer the question: Does Bt corn pose a threat to monarch butterflies? The answer, supported by science, is that there is no significant risk. The research found that Bt corn pollen levels usually had to be more than 1000 grains per square centimetre to have any negative impact on monarch caterpillars, let alone mortality. Scientists have concluded that monarch caterpillars in the environment are exposed less than 1% of the time to levels that even come close to that magnitude. The results of this research are discussed at length in a feature story that appears in the February 2002 issue of *Agricultural Research Magazine*.

Continuing GM fears

...a study, reported in *Nature* last November, by Ignacio Chapela and David Quist of the University of California, Berkeley, found DNA from GM crops in wild maize growing in remote mountains in Mexico. The wild maize was growing around 100 km from the nearest conventionally grown maize. The authors claim that the results confirm that there is a real concern that genes from GM crops could threaten the valuable diversity of native wild maize.

...English Nature warns in a recent report that GM crops could create superweeds. It is claimed in the report that research from Canada has shown that herbicide-resistant oilseed rape crops are cross-breeding at the edge of fields. Accumulation of such genes in weeds could lead to their becoming resistant to pesticide sprays, making them harder to control. The accumulation of two or three herbicide-resistance genes in one species – a process known as gene-stacking – is now widespread in Canada. Farmers in Canada are advised to leave a distance of 175 metres between GM crops, but the guidelines are voluntary; in the UK the existing separation distance is about 50 metres.