In a desperate effort to reverse its failing fortunes, the biotechnology industry and its supporters are putting their faith in the 'second generation' of genetically modified (GM) crops. It is claimed that many of these will bring consumer benefits by offering foods with enhanced nutritional value (so-called 'functional foods'). Other genetic modifications to the nutritional composition of crops are intended to facilitate food or animal feed production or provide ingredients for other industrial uses from cosmetics and personal healthcare to biodegradable plastics and biofuels. This briefing reviews what is under development and what the risks and benefits may be.

Why Are Functional Foods Being Developed?

The term, 'functional food' has no clear scientific basis or legal definition. It is primarily a marketing term coined in Japan in the 1980s and such foods may also be referred to as 'designer foods', 'nutritionally enhanced foods' or 'nutraceuticals'. For the purpose of this briefing, functional foods are defined as 'foods with ingredients that claim to provide a health benefit to consumers beyond the nutritional benefits ordinarily provided by the foods themselves'. Non-GM functional food products already available in the UK include yoghurts with 'bio' cultures, spreads with cholesterol-lowering compounds, bread with fish oil, and soft drinks with added fibre.

The market for functional foods is being developed in response to the growing public interest in the links between diet and health. Foods with enhanced nutritional benefits are seen by companies as a way to achieve added-value growth and profitability in an otherwise highly competitive food market with tight margins and slowly growing food sales. Therefore, food companies around the world are restructuring their operations and spending literally hundreds of millions of dollars to develop and market functional food and beverage products. The real value of functional food to companies is not in their potential to improve the health of the nation (where is the commercial value in that?) but in the 'exciting opportunities' functional foods offer to 'food manufacturers and retailers to add value and differentiate their products'.

Over recent years, many major food companies and ingredient suppliers have declared their commitment to functional foods. These companies include Nestlé, Kellogg, Unilever, ConAgra, Nabisco, Quaker and virtually every major European dairy company, as well as the 'life sciences' corporations, DuPont, Monsanto and Novartis. Many of these companies have set up 'functional food' or 'human health' divisions to exploit market opportunities. For example, Novartis and Quaker have recently announced the formation of the Altus Foods Company to produce foods with health benefits.

Yet there are those who believe that the rhetoric and claims made for functional foods are seriously over-stated: "To date, marketing hype appears to have outrun scientific evidence, inviting the conclusion that the whole concept of functional foods has been over-promoted, just another food fad for the high-tech era."
developing crops with genetically altered nutritional profiles and foresee a role for biotechnology in developing functional foods and ingredients. The UK Government’s research council, the BBSRC, also believes that, “scientific advances, including those in molecular genetics, now make possible a more rational and systematic modification of raw material” leading to “quality enhanced at primary production rather than processing”.

To date, only two GM products with altered nutritional traits have received market approval - both in the USA - although neither is in commercial use. Both are oilseed crops with an altered oil composition - a soybean with increased oleic acid (DuPont) approved in 1997, and a high lauric acid oilseed rape from Calgene/Monsanto approved in 1995. According to Monsanto, the latter is no longer being grown and there are no plans to introduce this crop into Europe. DuPont’s product is still under market development in the US, and although the company has sought European marketing approval, it does not expect this to be forthcoming in the foreseeable future.

Although no other GM functional food products have yet reached the market, there are several areas where GM techniques are being applied to crops to produce altered nutritional profiles:

- increasing the content of vitamins, minerals and other micronutrients;
- modifying fats and oils;
- altering the starch and sugar content;
- altering protein/amino acid profiles;
- reducing levels of anti-nutritional/allergy factors;
- flavour enhancement.

Vitamins, minerals and other micronutrients

There has been much recent publicity over the GM rice being developed by Swiss researchers to have enhanced levels of beta-carotene (converted to vitamin A in the body) and iron. This so-called ‘golden rice’ has been promoted as a means of addressing the problems of vitamin A and iron deficiencies in developing countries (see centre pages). Other work to enhance micronutrient content through genetic modification is likely to be aimed at providing alternative sources of ingredients (e.g. beta-carotene, vitamin E) for the food and food supplements industry, primarily in developed countries.

Companies are also altering levels of other chemicals which may be connected with health. For example, AstraZeneca is exploring genes (licensed from several other companies) which, it is suggested, could reduce the incidence of heart disease and some types of cancer.

The role of functional foods is to provide companies with new marketing opportunities rather than address underlying nutritional problems.

The introduction of GM nutritionally altered foods raises serious safety questions. New systems of safety assessment will have to be developed and regulation of the health claims that can be made for any altered food must be introduced as a matter of urgency. If consumers are not to be misled, all functional foods should be tested to determine whether they provide any real benefit. This should not apply only to the basic ingredient but also to the final product to avoid foods with, for instance, a high fat content being labelled as ‘healthy’ because it has some added micronutrient.

For the biotechnology industry, an important challenge exists in terms of consumer acceptance. Because there is, in fact, no real consumer benefit that can be detected in the majority of nutritionally altered GM foods being developed, in the present climate it seems unlikely that they would be marketable in the UK. Since GM foods are already so stigmatised, the industry’s hope that GM functional foods will reverse their failing fortunes seems rather forlorn.

This briefing is based on a research report ‘Biotech - the next generation. Good for Whose Health?’ by Sue Dibb of the Food Commission and Sue Mayer of GeneWatch UK. The full report is available from either organisation for £40 (£10 for individuals and not-for-profit organisations).

References

4. Tribune Business and Market News, 10th February 2000. ‘Quaker Oats makes deal with Swiss firm to produce healthier food’.

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improving public diet-related foods in reducing There is little evidence to support the role of functional foods in reducing diet-related disease and improving public health

The challenge for safety assessors is that any unintended alterations have to be identified and their significance determined. As one expert has said: ‘Safety testing will have to be adjusted for the ‘second generation’ of food plants, which are modified to improve food-quality traits... These must undergo extensive toxicological and nutritional assessment with a combination of in-vitro and in-vivo techniques as required for novel foods in general’. As yet, appropriate testing systems have not been defined or agreed upon.

General safety questions
It is also important to consider the nutritional impact which such altered foods may have on the overall diet of those consuming them - particularly for ‘at risk’ groups such as infants, young children and pregnant women. Fortification of foods with relatively high levels of a small number of micronutrients may cause an imbalance in dietary intakes and the addition of one nutrient may lead to disturbances in the utilisation of others. It is now becoming clear that plants contain a great many different micronutrients and many interactions take place. For example, vitamin C enhances iron absorption while calcium may reduce it. Potential risks include:
- Consuming high levels of vitamin A during pregnancy may increase the risk of birth defects.
- Excessive intakes of vitamin A from overuse of supplements are toxic and can cause damage to the liver and cell membranes.
- Increased risk of heart disease and cancer are associated with high levels of iron.

Despite such risks, there is no specific legislation addressing functional or nutritionally altered foods in the UK, although the Food Safety Act (1990) prohibits false and misleading advertising of food in general and more specifically prohibits ‘medicinal’ claims for foods (i.e. that a food can treat, cure or prevent a disease). However, this does not address claims that a food is ‘healthy’ or has some general nutritional benefit. Therefore, concern is increasing about the proliferation of health claims for ‘functional food’ products such as infant foods containing beta-carotene which has antibacterial properties. The removal of allergens from allergy-triggering foods such as peanuts, rice and milk is also under research. The claims made for GM nutritionally altered foods and the alleged consumer benefits will bring are overstated. It is clear that they are a long way from being used to produce the human milk protein, lactoferrin, found in colostrum (the first breastmilk) which has antibacterial properties. The removal of allergens from allergy-triggering foods such as peanuts, rice and milk is also under research. Any benefits will be limited to those able to afford the higher prices.

Assessing the health benefits of levels of individual chemicals in foods is difficult. Epidemiological data supports the need for greater consumption of fruit and vegetables and other foods rich in micronutrients in diet-related disease prevention. However, in general, evidence to support the health benefits of increasing the consumption of individual micronutrients (the approach taken with GM nutritionally altered foods) is less convincing.

Modifying fats and oils
Efforts to modify the oil composition of oilseed crops such as oilseed rape and soybean have largely focused on producing sources of more stable oils to reduce the need for blending or processing, or alternative sources of stability oils. Some of these novel oils are intended to substitute for tropical oils (e.g. palm or coconut) or existing specialty oils (e.g. fish oils, evening primrose oil). Such developments are primarily intended to benefit food processors and producers or other industrial users rather than consumers. Even those intended to eliminate the need for chemical hydrogenation in processing (which results in the production of harmful trans-fats) are unlikely to offer a significant health benefit as this is achieved by increasing the level of unhealthy saturated fats.

Much of the early optimism for producing designer oilseeds has been tempered by setbacks in obtaining high yields of specific novel fatty acids in GM crops. Any products will have to be processed separately from conventional crops and the costs of harvest segregation and separate transportation will add considerably to the price. The final product will therefore only be applicable to specialist niche markets that bring a premium and any benefits will be limited to those able to afford the higher prices.

Altering starch and sugar content
Most research into genetically modifying the starch content of sugar beet, potatoes and maize is primarily aimed at producing alternative sources of starch-rich starchy for industrial purposes. However, spin-off research claims that it could be possible to produce ‘healthier’ chips from potatoes which have been modified to have a higher starch content and so absorb less fat. Another area of interest to the food industry is that of fructans found in artichokes, onions and garlic. Although sweet-tasting, these are non-digestible (and therefore non-calorific) carbohydrates. Fructan-encoding genes have been introduced into chicory and also into sugar beet to produce sugar that has half the calories of conventional sugar and is intended for the lucrative ‘low calorie’ or ‘slimming’ foods market.

Other applications
It has been proposed that biotechnology could be used to improve the protein content of staple crops in developing countries. Some success has been reported for sweet potato and future work may involve cassava, rice and plantain. Modifying protein composition is also being used to improve the dough-making characteristics of wheat with potential benefits to the baking industry and to improve the quality of animal feeds. Proteins are also of interest to the pharmaceutical and infant formula markets. Biotechnology is being used to produce the human milk protein, lactoferrin, found in colostrum (the first breastmilk) which has antibacterial properties. The removal of allergens from allergy-triggering foods such as peanuts, rice and milk is also under research. Although no such products are close to being marketed.
Altering nutritional composition raises important questions about the safety of the final food

Will GM Nutrionally Altered Foods Be Safe to Eat?

Altering nutritional composition raises important questions about the safety of the final food in two respects - does the genetic modification result in any unexpected, potentially harmful changes and are there any problems with nutritionally altered foods more generally (however they are produced)?

GM and the potential for new toxins

The application of GM to the nutritional composition of foods involves altering the plant’s basic biochemical process by modifying the synthetic pathways which determine its chemical composition. This may alter other metabolic pathways and lead to the production of not only the expected compound but also unexpected ones. Some unexpected and unintended effects have already occurred:

- When Monsanto introduced genes to produce beta-carotene and other carotenoids in oilseed rape, this resulted in a decrease in tocopherol (including vitamin E) levels and alterations to the fatty acid composition which were unexpected and which are so far unexplainable25.
- When researchers in Germany tried to reduce the sugar levels and increase the starch content in potatoes (using genes from yeast and a bacterium), starch levels were actually reduced. Many unexpected compounds were also produced as a result of disturbances to the potato’s metabolism26.
- In high-stearate oilseed rape, the stearic acid was found to be present not only in the storage oil but also in the membrane lipids of the seed. The seeds tended to have relatively poor germination rates and the high-stearate properties were gradually lost when the GM plants were grown on a field scale27.

The goal of virtually eliminating VAD by the year 2000 has not been achieved

Continuing VAD would therefore seem to demonstrate a failing on both counts. The WHO consider VAD to be “...a test case of political will, and managerial capacity to implement known technologies and known solutions”27.

Encouraging the growing and consumption of more fruit and vegetables and animal products such as eggs and cheese would have wider nutritional benefits than the GM rice. Improving incomes, education and sanitation or giving supplements to those in need could prevent deaths and disability arising from reasons other than vitamin A deficiency alone.

However, in the same way that GeneWatch UK has argued that people in Europe should have a say over what they eat, those who are at risk from vitamin A deficiency have to be included in the process of finding the best and most sustainable solutions - they understand their problems far better than any scientist. Rather than being used as pawns in a distant political debate about the pros and cons of GM foods, it is the poor and disadvantaged who must be centrally involved in weighing up the options.

The application of GM to the nutritional composition of foods has had some unexpected results

The goal of

Alternative methods of control

Technically feasible, relatively cheap and effective ways of reducing VAD are already available and practised. These include:

- *Supplementation* programmes using high dose vitamin A capsules - ideally twice yearly – which are now extensive.
- *Fortification of foods* – adding vitamin A to foods before they are purchased – can also be very effective and this approach is expanding21. However, as with supplementation programmes, this strategy requires external inputs, foreign currency and a sustainable distribution system.
- *Dietary diversification* – where a wider based diet is encouraged - is considered an important dimension of control and is likely to be a more sustainable approach in the long term. Home gardening and women’s education have both been shown to improve long-term consumption of foods that are rich in vitamin A20.

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