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Plant biotechnology, the regulator and the consumer

Janet Bainbridge

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Abstract

The use of genetic modification (GM) technologies to modify food crops provides one of the most hotly debated and often discussed applications of science. As the science develops, new generations of GM crops will be produced and current consumer views might change. This brief paper discusses mechanisms by which the complexity of decision-making at the regulatory level might be better understood by the public and hence provide tools for individuals to inform their own views and purchasing choices.

Janet Bainbridge
Chaired the Advisory Committee on Novel Foods and Processes (ACNFP) from1997 to 2003 and now chairs the Scientific Advisory Committee on Genetic Manipulation (Contained Use) (SACGM); she also sits on the British Potato Council and chairs their R&D committee. She is a trustee of Sense About Science and has had many other advisory and consultancy roles.

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Professor Janet Bainbridge OBE
Senior Specialist Advisor (Government and Europe),
OneNorthEast,
Stella House,
Newcastle Upon Tyne,
NE15 8NY, UK

Tel: +44 (0)191 229 6581
Fax: +44 (0)191 229 6237
E-mail: Janet.Bainbridge@onenortheast.co.uk

Some ten thousand years ago the industry that we now know as modern agriculture, primary food production and the base of our food chain was already selecting plants to develop for new crops, disease resistance, vigour and high yields, and to optimise the yield for the local conditions. Gradually over the centuries we developed the strains continuously, without having much knowledge of the actual internal mechanisms of plant genetics and biochemistry but then suddenly, in the 1970s, we were able to understand more about plant genes and the structural and metabolic activities that the 30,000 or so genes in a typical plant cell encode. With this knowledge we have been able to modify the genetic information in living organisms in a new controlled way, by transferring one or more pieces of DNA directly between them. This genetic modification has led

us to new insights of metabolism and is the basis of a huge industry with many commercial applications in drug development, for example, in drug development. Most of these examples involve the genetic modification of microorganisms such as yeasts and bacteria. When applied to crop plants, genetic modification can involve gene transfer either from another plant species, or from a completely different organism such as a bacterium or virus. The process differs from conventional breeding in its sophistication and man's ability to direct the changes; but in other ways there are major similarities with early plant breeding techniques. One absolute certainty is that we understand far more of the genetics of genetically modified (GM) crops and how their genotype influences the plant metabolism than we do about any conventionally developed non-GM plants.

Armed with knowledge, the consumer will be able to make rational choices

Never has any technology been subject to such public scrutiny, and never have so many claims been made about potential benefit, nor so many counter-claims about possible harm been expressed. The GM review was commissioned to address the state of the art science surrounding GM crops with a focus upon topics shaped by public questions and concerns. It actively engaged with the public to explore fully different viewpoints.[1] This report attracted wide public and media interest, both in the UK and abroad. Comments submitted were then discussed by the panel early the following year and the second report moved the debate further forward. The science continued to develop and probably the most significant intervening development was the release of the results of the UK farm-scale evaluations of GM crops. The second report was published in January 2004 and together the two reports represented the most comprehensive engagement of scientists, social scientists, non-governmental organisations (NGOs), regulators and the general public in GM issues and raised the level of the discussion. If the potential benefits of GM technologies are to become reality we must look at public good breeding objectives (and be aware that these may vary in different situations) and continue to ensure that there is greater openness and honesty in discussions that value all inputs from constructive contributors. The future of so-called good plant breeding was fully discussed by Philip Dale.[2]

But why is the consumer so confused? There are only two ways to understand the collective consumer view; firstly by a variety of polls, meetings and other sociological techniques used to elicit responses from groups of 'representative' consumers. The other, far more effective, way is to give consumers choice and see how they spend their money in the supermarket. In 1999 when two leading UK supermarkets put GM tomato puree on the shelves next to the non-GM counterpart, the proof was in the sales; the GM was seen as better value and better flavoured and, thus, outsold the conventional by two to one. However, despite clear evidence that consumers saw the added value in the product, it was taken off the shelves in a wave of panic when activists stirred up near hysteria in relation to GM foods. Consumers base their decisions upon tangible aspects such as quality, price, taste and safety. I believe that with clear labelling, a basic general understanding of the technology and an understanding of the rigours of the regulatory systems, UK and European consumers will act no differently from millions of consumers around the world who have been buying and eating GM products for years. In the case of GM foods the customer will, and should, decide.

In order to make robust decisions it is important to have evidence. Some interesting developments are being devised and implemented to help the public access some of the facts, arguments and uncertainties that help inform regulatory processes and hence be well placed to make their personal risk assessments or purchasing decisions. One

of the most promising developments to provide help for the future generations is the effort being made to address some of these issues via the UK school curriculum. A new science curriculum, '21st century science' (coordinated by the Nuffield Foundation and the University of York[3]) is currently being piloted in British schools. It attempts to encourage the student to understand the processes of science, increase scientific literacy and teach the topics that everyone needs to understand in order to formulate rational personal opinions.

It is all too easy to generate publicity and worries from unsubstantiated claims, whether they come from NGOs or scientists. Public debate is often led by various commentators, not by the views of the public at large. However, little is known by the public about how scientific peers assess science. Peer review is a long-established mechanism whereby scientists publish their work, explain how the results were generated and hence invite others to repeat the findings. It is essential that this process is adhered to especially where the results could have implications for health, the environment etc. Scientists who publish via the media without going through the review process are living a dangerous existence. Peer review is the first stage, work has to be repeatable – the more significant the finding, the more interest there will be on trying to repeat and build upon the work. If there are problems they will soon come to light but often the damage is done to the technology since the public have read the 'bad news' in the media; the peer-reviewed, accurate results are unlikely to be given much media space.

Applications of any scientific discovery must be considered on a case-by-case basis

Regulatory framework are complex and based upon risk assessment

The peer review process is poorly understood by the public

However, considerable harm might have already been done. When Putszai claimed, on television on 10th August, 1998, and later in a press conference in the House of Commons on 12th February, 1999, that feeding rats with GM potatoes caused them damage, there was a huge outcry and GM technology per se was implicated as harmful to human health. However, eventual publications in respected peer-reviewed journals showed that the results were not valid and the experimental design was flawed, and the original authors conceded: 'After careful investigation we found no convincing evidence of adverse effects from GM potatoes'.[4,5]

Immediately prior to the report of the farm-scale evaluations released in October 2003, a large number of anti-GM headlines appeared in UK newspapers clearly designed to influence public opinion. Once the report was published many newspapers still stated the results as 'the end of GM in the UK'. In fact, the trials did not assess the effects of GM crops but rather the effect of different types of weed control. They have almost nothing to do with genetic modification. On 9th March, 2004, Margaret Beckett MP, Secretary of State for Environment, Food and Rural Affairs, made a statement in the House of Commons 'there is no scientific case for blanket approval for all uses of GM equally there is no scientific case for a blanket ban on the use of GM'; again stressing the importance of case-by-case analysis.

Scientific discovery is rarely simple; living systems, whether at the cellular or the macro-environmental level, are extremely complex and risk assessments are often made on evidence that is at the limits of our knowledge and, hence, incomplete data sets may have to be utilised. This is why the skills and knowledge of a range of experts in different fields, who come together as regulators to make recommendations regarding the applications of the science are so crucial. Their work is often complex, defined by explicit statutory frameworks and, in the UK, is in the public domain with committees all having websites, annual reports and often holding public meetings. It is nonsense to judge any new scientific discovery or scientific application as 'good' or 'bad'. If you consider any fundamental technology developed in the 20th century it will have possible harmful applications as well as positive benefits to health and society.

New techniques must be validated before sustainability of incorporation into regulatory frameworks

Hence, regulatory frameworks supported by effective enforcement regimes are essential and will scrutinise complex data sets to formulate case-by-case recommendations. The National Council for Women in their publication 'Deserving of Answers' stated 'Regulation must keep apace with that of research. Consumer confidence is dependent upon transparent and effective application of the rules together with adequate punishment of offenders'.[6]

Beckett went on to echo this view '. . .they want strong regulation and monitoring and in addition, want some framework of rules for co-existence of GM and non-GM crops, and customers want a clear regime for traceability and labelling so that they can make their own choices'.

In Europe the regulatory process for GM foods is rigorous and robust and has been fully described[7] and, thus, will not be discussed in detail herein. It is an evidence-based safety assessment and risk analysis that recognises the consumption of food is not risk free and requires any novel (including GM) food to be at least as safe and nutritious as any traditional food it replaces or complements. The regulatory process is open and transparent and it requires the experts who sit as regulators to be totally independent and to state annually any possible conflicts of interest. The process has been variously described both as too rigid, slow and ponderous and too lax, superficial and narrow. We must never be complacent, but these facts suggest that we probably have it about right! But we must always be vigilant.

As GM science moves on, so will the challenges presented to regulators by applications of increasing complexity. As we have to regulate more complex foods, especially those with multiple genetic modification, we will need to develop new tools for analysis and interpretation of data. Here again, we will look to advances in science and technology: some of the new tools such as metabolomics and proteomics are already available and regulatory committees are looking at how new screening and profiling techniques can be evolved to cope with addressing uncertainties and fill gaps in our knowledge. When they can be validated as useful tools for informing and adding to the database of evidence for specific applications they will be incorporated into the validation process.

There has never been such detailed scrutiny of any conventional foods (primary or processed), neither has any harm or toxic or nutritionally deleterious effect ever been recorded as a result of the cultivation or consumption of GM food that has been through the safety procedures and given a positive risk assessment by the Advisory Committee system.

We must not be complacent and scientists have identified areas where we need to be extremely vigilant:

- toxicological and nutritional differences in GM crops/foods;
- fate of transgenic DNA.

One concern is that GM crops may give rise to serious new food allergies; however, changes in allergenicity are not assessed in a regulatory framework and not evaluated during the breeding of conventional crops. GM technology allows for the introduction of a particular gene construct for a new protein, and the potential allergenic effect of that protein is a focal point for safety assessment. In addition, the regulatory process, with its case-by-case approach, must take into account the possibility of exposure to a GM protein, especially if it is expressed in a diversity of different GM plants and, thus, introduced into a diverse range of foods. In the hypothetical case, where a GM allergen was not recognised by regulatory screening, and its effects emerged in the longer-term avoidance of the allergenic protein by the consumer could be difficult. However, this scenario is theoretically possible but unlikely for a number of reasons. Avoidance of the GM allergen, once known, would depend

upon the relative effectiveness of labelling, traceability and recall systems and it would be for the regulatory system to ensure that, once recognised and known, the allergen should be withdrawn from the marketplace or labelled in a fail-safe way. There is an accepted test of allergic potential based upon a set of standards; these tests for potential allergens are not ideal and there is some contention as to their value, hence these tests are continually subject to development for improvement in sensitivity and specificity. Concomitantly, medical science is trying to unravel more clarity about the human allergic response.

The fate of transgenic DNA can be monitored

The GM foods currently being consumed have not demonstrated any evidence of allergic reactions and it is generally accepted that it is easier to assess the risk of introducing allergenic proteins by altering the allergenic composition of the target crop after use of GM breeding than it is in conventional breeding. However, our relative lack of understanding about allergies and the factors important in sensitisation and elicitation of an allergic response suggests that we should continue to exercise caution when assessing all new foods and animal feeds derived from GM crops.

The next generation of GM crops will be complex to regulate but potentially have significant benefits

The so-called 'second generation' of GM crops includes crops and their products that will decrease the level of anti-nutritional factors (eg toxins), increase levels of health-promoting factors (eg antioxidants), and modify levels of macro- or micro-nutrients (eg vitamins). The absence of observable adverse effects does not mean that these can be ruled out completely since there is no epidemiological monitoring of those consuming GM foods. The long-term assessment of health effects for whole foods and feeds is extremely difficult to do. It is not the same as post-market monitoring and surveillance for a single substance such as a medicine or an environmental pollutant. Health professionals and scientists and are working to detect potential human health effects of food in general, but nothing is available for GM foods. Technically it is likely to be very difficult, owing to the complex formulations of our manufactured foods, the variety of foods available, the difficulty in recording dietary intakes and the need for very long-term follow-up. These problems cast doubt on the validity of the monitoring process.

Long term monitoring of health effects is technically very difficult for any products in the human diet

The fate of transgenic DNA is less problematic to determine. DNA is a universal component of all living organisms and is ingested in raw fruits and vegetables; it is typically not removed by extraction and processing technologies used in the food processing industry. In some purification processes such as refining of edible oils or purification of sugar, all or most of the DNA is removed. Heat treatments might not remove DNA but are likely to damage it and cause partial or total inactivation and breakdown. In the gut it is partially broken down but fragments of DNA have been detected and it is theoretically possible that transfer into gut bacteria is possible. There are a series of natural barriers to prevent integration of this DNA and the expression of foreign genes by gut microbes, therefore the process is not likely to have significance. However, if the new DNA does give the bacterial cells a selective advantage it might be stably incorporated. This is a possibility if the DNA carried an antibiotic resistance gene and the use of antibiotic resistance genes to act as markers for the selection of a new GM organism is no longer used. While there is valid scientific agreement that antibiotic-resistant markers should not be used, there is a great deal of debate and disagreement about the impact since there are experimentally supported arguments that any rare resistance gene transfer event from a GM plant or food would have no impact as antibiotic resistance is already widespread as a consequence of antibiotic usage in medicine and animal feed.

Food and feed studies have repeatedly failed to demonstrate any transgenic DNA in milk, eggs or meat from animals fed GM crops

Food and feed safety studies have repeatedly failed to detect introduced feed DNA in milk, eggs or meat from animals

fed GM crops. We must never be complacent but must look forward to the considerable benefits that will be realised by the development of the next generation of GM crops and we must ensure that we do not cause general public confusion by stating generalities about the potential and safety of the technology.

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