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Review

A perspective on genetically modified food crops

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Genetic modification is the alteration of genetic material that would not occur naturally. It can be used as a tool to improve the quality of foods. Through genetic modification foods can be produced in larger quantities by increasing its resistance to pests and adverse weather conditions. Their protein and vitamin content may also be increased thus making them more nutritious. There are also claims of potential risks such as possible allergic reactions to modified proteins. To date, no international consensus has been reached for evaluation of the safety of genetically modified plants for consumption. Over the last decade, the safety of genetically modified crops in animal feed or foods for human consumption has been routinely tested in some countries. Protein- and DNA-based methods have been developed for detection of genetically modified organisms. Worldwide legislation now faces questions on the use and labeling requirements of genetically modified crops and their derivatives. Still, there are concerns about the safety of genetically modified crops. Also, genetically modified crops could contain toxic substances or larger amounts of heavy metals and the crops might not be substantially equivalent in genome, proteome, and metabolome to unmodified crops. An additional concern is that contrary to expectations, genetically modified crops may be less nutritious; for example, they might contain lower amounts of essential phytoestrogens, needed to protect against heart disease and cancer. This review will focus on perspectives of the genetically modified food crops.

Key words: Food crops, genetic modification, transgenic, biotechnology-derived crops.

INTRODUCTION

New biotechnological methods to improve the quality and quantity of foods have been recently used to meet the demands of an increasing world population (Lehrer and Bannon, 2005; Plahuta and Raspor, 2007; Bennett et al., 2005). Use of recombinant DNA technologies has led to governmental regulations to assess their safety (Plahuta and Raspor, 2007; Weiss et al., 2006).

Since the mid-1990's, genetic modification (GM) is a rapidly growing and controversial method that can boost agricultural productivity, but the technology is not fully understood by the consumers (Bennett et al., 2005). For example, the transfer of genetic material from *Bacillus thuringiensis* (Bt) into corn, produces a variety that contains Bt-toxin, selectively poisonous to insect pests. The term ―biotechnology derived‖ (BD) has been proposed as an alternate to ―genetically modified‖ foods (Mehendale, 2004; Heckmann et al., 2006).

The world population is expected to double to more than 10 billion people by the year 2050. By increasing crop resistance to environmental factors, growers expect farming in parts of the world now unsuitable for agriculture (Bakshi, 2003; Mehendale, 2004; Plahuta and Raspor, 2007).

The breeding of new plants by recombinant DNA technology is both economically and nutritionally important and expected to increase foods' nutritional quality, shelf life, yield, pest and disease resistance, tolerance to environmental stress or, as in case of fruit tree breeding, shortening of the juvenile phase for the acceleration of the breeding process (Weiss et al., 2006; Bakshi, 2003).

Plants such as maize, soybeans and canola have been made resistant to insects and/or more tolerant to herbicides. In Europe, however, these traits are not perceived as beneficial to the consumer in terms of reduced prices or increased product quality, but rather as benefits for the companies that own the technology and the farmers that grow these crops (Weiss et al., 2006; Bakshi, 2003; Heckmann et al., 2006; Moseley, 2001). Also, environmental concerns, transparency of the regulatory mechanisms and mistrust of government bureaucracies contribute to fuel debates about the safety

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of modified genes, that is, potential gene flow to other organisms, destruction of agricultural diversity, antibiotic resistance and other problems (Gaskell et al., 1999; Bakshi, 2003; Heckmann et al., 2006). Ethical issues also contribute to reluctance in adopting these new technologies (Arvanitoyannis and Krystallis, 2005).

In 2002, Brazil and South Africa joined the United States, Argentina, Canada, and China as leading producers of GM crops. Together, these countries produce 99% of GM foods. China and South Africa experienced the greatest annual increases, planting one-third more GM hectares than they did in 2002 (Gaskell et al., 1999). In the US, GM plants have been approved for food use since 1992. In 1997, GM soybeans represented approximately 10% of the total harvested in the United States and, in 2004, it increased to almost all of the soybean production (Markoulatos et al., 2004).

POTENTIAL HEALTH EFFECTS OF GENETICALLY MODIFIED FOODS

Adequate regulation to ensure that BD foods are not knowingly toxic, allergenic or carcinogenic is prioritary (Emiroglu, 2002). By itself, regulation cannot guarantee that a GM food is entirely safe (Emiroglu, 2002; Hu et al., 2005; O'Fallon et al., 2007).

It has been argued that GM crops cause increased antibiotic resistance, presence of toxins, fungi, or toxic metals and increased cancer risks in humans, and that it degrades the nutritional food value, produces new allergens and other potential risks (Bakshi, 2003; Gizzarelli et al., 2006; Warner, 2002; Heckmann et al., 2006; Dean and Shepherd, 2007). DNA breakdown during digestion eliminates the possibility that intact genes capable of encoding foreign proteins will be transferred to gut flora (Plahuta and Raspor, 2007).

Production of GM foods raises broad socio-cultural and ethical issues at the national and international levels. Law making in this field has to take into account multiple- and sometimes conflicting- policy objectives, including policies to (1) protect the natural environment and biological diversity; (2) safeguard diverse cultural and religious traditions; (3) optimize GM production of quality foods; (4) ensure socially equitable distribution of benefits, and (v) hold governments and businesses accountable for food safety and adequate information to consumers (Sand, 2006).

GM LABELING AND PRODUCT TRACING REQUIREMENTS

Labels make information available to the consumer and thus contribute towards acceptance of GM products (Emiroglu, 2002; Hu et al., 2005; Morgan and Goh, 2004). The influence of labeling on purchasing behavior (Noussair et al., 2002). GM allows creating new transgenic organisms (Lang and Hallman, 2005; Bakshi, 2003; Hu et al., 2005). Consequently, these products need also be covered by new legislation (Kuiper et al., 2001). Safety requirements and full disclosure of safety-related information are indispensable to ensure the safety of GM products (Emiroglu, 2002). Foods often contain varying amounts of GM corn, soybeans and canola mixed with ordinary varieties (Lang and Hallman, 2005).

Turkish law already regulates the labeling, tariffs and price lists for retail goods and services (Emiroglu, 2002). It places general obligations for traceability and labeling requirements and introduces specific requirements that impact all stages of food production. The main provisions of this legislation ensure adequate labeling of GM foods (Livermore, 2003). International regulations should be put in place accordingly (Emiroglu, 2002). Regulations in the UK state that field-testing and safety assessments must be carried out on each GM crop before authorization for use as food. Broader health concerns of GM crops are not included in current British law (Dean and Shepherd, 2007). European community regulations require specific labeling when a product is determined not to be equivalent to existing foods. Labeling is also required if there are health or ethical concerns (Dean and Shepherd, 2007).

Exporters must ensure the unique identification code (s) assigned to products derived from GM. To comply with EU regulations, the summary of the EU Directives and Regulations related to protection of nature and biodiversity is available for consultation (Arvanitoyannis et al., 2006). The usefulness of these complex regulations regarding consumer confidence remains to be seen (Livermore, 2003). The evidence suggests that GM labeling and product tracing requirements impose significant barriers to trade of GM foods in the marketplace (Morgan and Goh, 2004).

METHODS FOR DETECTION OF GENETICALLY MODIFIED PRODUCTS

Development and validation of quantitative methods for evaluation of GM products is critical due to restrictions imposed by mandatory labeling. The European Commission's Reference Laboratory provides official methods for event-specific detection and quantification of materials derived from GM crops. Current methods for the relative quantification of recombinant DNA are based on real-time PCR (Yoke-Kqueen and Radub, 2006; Engel et al., 2006).

The latest developments and future perspectives are centered on quantification, analysis, number of samples to be screened and lack of reference materials (Engel et al., 2006). Present methods include nucleotide-based amplification, protein-based and enzymatic techniques. Protein- and DNA-based methods, such as enzyme-

linked immunosorbent assay, western blots, and qualitative and quantitative polymerase chain reaction have been used for detection genetically modified organisms (Markuolatos et al., 2004; Yoke-Kqueen and Radu, 2006).

Several PCR-based methods for quantitative GM detection have been developed recently. New methods are still needed to enforce recently introduced labeling requirements (El-Sanhoty et al., 2006). Development and validation of new profiling methods such as DNA microarray technology, proteomics and metabolomics is needed for determination of potential negative effects of GM products (Kuiper et al., 2001).

TO BUY OR NOT TO BUY GENETICALLY MODIFIED FOODS

Biotechnology has the potential to lower food prices and environmental impact of agriculture but a number of real and perceived risks to the environment and human health still exist (Lusk et al., 2006). Health and environmental concerns are likely to be significant factors in considering consumer perceptions and behavior. Mandatory or voluntary labeling must be used to identify GM products (Emiroglu, 2002). The US and Canada markets have gained considerable experience in assessing consumer preferences and their temporality (Morgan and Goh, 2004). Consumers with different socioeconomic and demographic attributes have diverging views of food biotechnology only when its use brings specific benefits to them (Hossain et al., 2003).

Government Agencies generally agree that GM foods are beneficial to the consumer. These views may or may not be in agreement with perceptions from the general public or those of independent organizations. Europeans remain skeptical of GM foods. There is limited interest on how individuals learn about their risks and benefits, along with the influence of information on consumer perceptions (Costa-Font and Mossialos, 2007).

Consumer acceptance of GM foods remains a critical factor that will determine the future of food biotechnology. Despite the enormous importance of the subject, reliable information about consumer awareness and perceptions of GM foods is rather scarce (Hossain et al., 2003). There are unconfirmed concerns about the transfer of genes from one species to another, or about antibiotic resistance from GM crops to animals. The debate over genetic modification remains intense. Claims that GM is ―tampering with nature‖ or ―playing God‖ are prevalent in some societies or sectors. Future large-scale growing of GM crops may have implications for biodiversity, the balance of nature, wildlife and the environment (Dean and Shepherd, 2007; Bakshi, 2003).

THE FUTURE

Proponents of GM herald it as the technology for the future promising to solve the problem of world hunger by improving agricultural methods, sustainability, food safety and profits. A major argument put forth by proponents of biotechnology is that its use may lead to the development of new and improved products with desirable attributes. The potential nutritional and environmental benefits derived from biotechnology, the argument goes, outweigh the small risks, if any, that might be associated to GM products. Whatever the perspective, there is no doubt that adoption of GM technology is increasing on a global scale (Morse et al., 2006). Despite the promise of biotechnology, a number of real and perceived risks to the environment and human health exist (Lusk et al., 2006; Emiroglu, 2002; Bakshi, 2003).

New technical and legal approaches are needed to gain consumer acceptance of bioengineered food products. Potential hazards should be identified and eliminated to minimize risks. The concept of equivalence of GM foods is not a safety assessment *per se*, but it helps to identify similarities and differences between existing foods and new products, which are then subject to further toxicological evaluation (Emiroglu, 2002; Hu et al., 2005). As stated before, it is necessary to develop and validate new methods for determining unintended effects that could result from genetic modification. An issue that will gain importance in the near future is that of post-market surveillance of foods derived from genetically modified crops (Kuiper et al., 2001).

Consumer confidence declines when a product is labeled as containing GM products, affecting their competitiveness. Consequently, food companies have chosen to avoid the use of GM ingredients. The risks and benefits of GM technology and the difficulties in detecting and, more specifically, quantifying the proportion of GM material in any given feed and food need to be clearly established (Ahmed, 2005).

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