Genetically Modified Food[1]

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What are GM foods?

A genetically modified (GM) food or genetically modified organism (GMO) results from the use of recombinant DNA biotechnological procedures that allow the genetic makeup of a food or organism to be altered in some way. This 'recombination' can be accomplished by moving genes from one organism to another or by changing genes in an organism that are already present. These changes result in the expression of attributes not found in the original organism. Examples of foods that have been genetically engineered include delayed-ripening tomatoes, pest-resistant crops (such as virus-resistant squash and Colorado potato beetle-resistant potato), herbicide-tolerant crops (such as bromoxynil-tolerant cotton and glyphosate-tolerant soybean), and many others. Genetic modification can be used to assist food growers/manufacturers in many ways such as improving crop yields, reducing insecticide use, or increasing the nutritional value of foods.

The first commercial food product developed from gene splicing (i.e., genetic modification in the laboratory) was the Flavr Savr™ tomato (Bruening and Lyons 2000). The Flavr Savr™ tomato had a gene added to prevent the breakdown of cell walls as the fruit ripened. The genetic modification allowed these tomatoes to remain firm even after extended shipping and storage times. First sold in 1994, the Flavr Savr™ tomato was only on the market until 1997, when Calgene, the company marketing it, ceased production.

Hard cheeses provide another example of the use of genetically modified organisms in food production. Chymosin, the primary component of rennet, is the milk-clotting enzyme used to make cheese and other dairy products. Traditionally, this substance was derived from the stomachs of calves. Most rennet used today is commercially produced by genetically modified microorganisms (most commonly with GM fungi). The FDA gave chymosin (from both traditional and GM sources) "generally recognized as safe" (GRAS) status, which makes it exempt from the usual premarket approval requirements (CFR [Code of Federal

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Regulations] Title 21). Approximately 90 percent of hard cheeses currently being produced are using an enzyme obtained from a GM source.

Types of GM Foods

A genetically modified organism (GMO) is one that has had its genetic material altered through one of several methods. Although traditional animal breeding and genetic modification through plant hybridization techniques are technically genetic modifications, these techniques pre-date recombinant techniques and typically are not considered GM. A genetically engineered (GE) organism is one where its DNA is modified using techniques that permit the direct transfer or removal of genes in that organism. Organisms that undergo genetic engineering are sometimes referred to as transgenic. Originally transgenic referred to an organism that had a gene from another (different) organism inserted into its genetic material; however, especially in news articles and on the Internet, the term *transgenic* frequently is used to refer to any genetic modification, regardless of the source and recipient of genetic material. One example of a transgenic GMO is "Bt corn," a transgenic corn variety containing a gene from the bacteria *Bacillus thuringiensis* (EPA 2002).

GM foods are classified into one of three generations. First-generation crops have enhanced input traits, such as herbicide tolerance, better insect resistance, and better tolerance to environmental stress. Second-generation crops include those with added-value output traits, such as nutrient enhancement for animal feed. Third-generation crops include those that produce pharmaceuticals, improve the processing of bio-based fuels, or produce products beyond food and fiber (Fernandez-Cornejo and Caswell 2006). Today, commercially available transgenic crops are only of the first-generation type.

Since 1987, seed producers have submitted nearly 11,600 applications to USDA APHIS (United States Department of Agriculture Animal and Plant Health Inspection Service) for field-testing (Fernandez-Cornejo and Caswell 2006). Applications peaked in 2002 with 1,190 approvals (Fernandez-Cornejo and Caswell 2006). More than 92 percent of the crops that have been submitted have been approved for trials. Most applications involve major crops, with more than 5,000 approvals for corn, the most commonly modified crop. The next most modified crops are soybeans, potatoes, and cotton. More than 6,600 of the approved applications include GE varieties with herbicide tolerance or insect resistance. If a GM product is deemed to be successful after trials and thought to be commercially viable, a company can petition for deregulation (i.e., allowing GE seeds to be sold). To date, APHIS has received 145 petitions for deregulation; of these, only 96 petitions have been approved. These include corn (30), cotton (15), tomatoes (11), soybeans (12), rapeseed/canola (8), potatoes (5), sugarbeets (3), papaya (2), rice (2), squash (2), and 1 each for alfalfa, plum, rose, tobacco, flax, and chicory (USDA 2014).

How could GM foods help consumers?

Industry has argued that we need GM foods because they will reduce production costs by reducing the need for additional chemicals (pesticides and fertilizers). Theoretically, these cost savings could be passed on to the consumer. The nutritional implications are also often cited as an obvious benefit for consumers, since the bioengineering could create plants that could produce more nutritious food. An example of one such product that is currently being evaluated is "Golden Rice" (GRHB 2014). Through genetic modification, this variety of rice is able to produce beta-carotene, which the body converts into vitamin A. Developing countries that rely on rice as their major food source often are the same countries that suffer from high rates of vitamin A deficiency (VAD). The World Health Organization in 2012 reported that about 250 million preschool children suffer from VAD. Providing these children with a source of vitamin A could prevent one-third of all under-five deaths (GRHB 2014).

Are there health concerns about GM foods?

One issue that is brought up from time to time is the potential for GM foods to cause allergic reactions. Food allergens are specific proteins naturally found in products such as milk, eggs, wheat, fish, tree nuts, peanuts, soybeans, and shellfish—these products are responsible for 90 percent of food-related allergies (FDA 2009). The fear is that if a protein from one of these food types were to be incorporated into a food where it is not normally found, people who are allergic to these substances could unknowingly consume them and suffer an allergic reaction. The approval process currently in place is designed prevent such a scenario by requiring each producer of a GM product to present scientific evidence that they have not incorporated any allergenic substance into their product. If this evidence cannot be produced, the FDA requires a label to be put on the product to alert consumers. To date, there has been no

documented allergic reaction associated with GM food (Lehrer and Bannon 2005).

What kinds of GM foods are sold in the US?

It has been estimated that more than 60 percent of food products in retail stores already contain genetically modified ingredients (Ahmed 2002). Commonly planted GM foods include many major agricultural commodities, with genetically modified plants accounting for 88 percent of the corn acreage, 93 percent of the soybean acreage, and 94 percent of the cotton acreage grown today. Worldwide, over 148 million hectares of GM crops were cultivated in 2010 (ISAAA 2010). It is important to point out that while the percentage of products containing at least one GM product is high, it should not be inferred that what we consume is 60 percent GM. Many products in that 60 percent may contain only a very small amount of GM-sourced product, such as the vitamins used to fortify them.

The Flavr Savr™ Tomato

The first genetically modified crop approved for commercial sale was the Flavr-Savr™ tomato. The product, developed by a company called Calgene, was approved by the FDA in 1993. It went on sale one year later, but in 1997, due to increasing public concerns and the need for specialized transportation equipment, production ceased. Calgene (which was subsequently bought by Monsanto) wanted to create a tomato with a vine-ripened taste that could withstand the rigors of shipping (Bruening and Lyons 2000). As previously noted, the Flavr Savr™ tomato was only on the market for three years, from 1994 until 1997.

Bt (*Bacillus thuringiensis*) Corn

Bt corn is a hybrid plant bioengineered to produce an insecticide. This induced insecticide provides effective, consistent control of pests such as the European corn borer and offers some protection against the fall armyworm and corn earworm. It does so at a lower cost than broad-spectrum, sprayed insecticides and with better results. In August 1995, both the EPA and the USDA approved Bt corn for commercial use as a human food product. The use of Bt (only) corn has increased dramatically from its introduction in 1996 to about 15 percent of total corn acreage in 2012, although those numbers have varied dramatically depending on the year (Fernandez-Cornejo 2012).

The StarLink Corn Incident

StarLink (Aventis Crop Science) is the trademark for a variety of corn that was genetically modified to produce its own pesticidal protein, Cry9C. This protein, like other GM insecticides, was effective in controlling certain insects and thus could eliminate the need for chemical insecticidal sprays. When questions about the potential human allergenicity of the Cry9C protein arose, investigations showed that the EPA had approved StarLink in 1998 for use only in animal feed and other industrial, nonfood uses. The EPA had found that, while no one had actually become ill, the protein in question, Cry9C, did not break down as quickly as other proteins found in GM corn. In September 2000, StarLink corn was found in the human food supply—first in corn tortillas, but later in other processed foods. This event triggered extensive publicity and increased public awareness of the presence of GM-derived foods in the American food supply. The US registration for StarLink corn was voluntarily withdrawn by Aventis Crop Science in October of 2000 (Taylor and Tick 2001).

L-Tryptophan

One incident that is routinely found on the Internet occurred in the US in 1989, when L-Tryptophan, a food supplement that can be produced by a GM bacteria through a fermentation process, was linked to 37 deaths associated with eosinophilia myalgia syndrome (EMS) (Williamson et al. 1998). Subsequent epidemiologic studies ultimately attributed the problem to the omission of an important purification stage from the process, not to the use of GM organisms in its production. This tragic case illustrates the importance of strict quality-control monitoring for all food products, regardless of their source.

How the FDA and the EPA Ensure Food Safety

There is no one statute or federal agency devoted to the regulation of GM foods. The public relies on the FDA for assurance that the foods we buy are safe and wholesome. Under the Food, Drug, and Cosmetics Act, the FDA has the authority to ensure the safety of most domestic and imported foods in the US market (except meat and poultry, which are regulated by the USDA). The pesticides used in or on foods are regulated primarily by the EPA, which reviews safety and sets tolerances (or establishes exemptions from tolerance) for pesticides. The FDA monitors foods to enforce the tolerances for pesticides set by EPA. Finally, USDA-APHIS controls the field trials of any GM crop that falls under permitting requirements.

The Future

The public controversy surrounding GM foods does not seem to be fading even in the face of all the scientific evidence supporting their necessity and safe use. Several states have tried to pass legislation requiring labeling of all foods contain GMO components, with Vermont successfully passing a labeling law in April 2014 that is to go into effect July 1, 2016 (Fusaro 2014). Several groups have challenged this legislation, while others are proposing/supporting alternatives. One such example is the Grocery Manufacturers Association (GMA) and other industry group's support of the Safe and Accurate Food Labeling Act (SAFLA), HR 4432. SAFLA would supersede state requirements and replace them with one for the entire US (van Laack 2014). Regardless of what happens with this labeling issue and other controversies surrounding GM products, one thing is for certain: the world's population continues to increase and the need for safe food will only increase along with it.

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