The Truth Behind Genetically Modified (GM) Foods

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Abstract

Since the 1970s, humans have used genetic modification to insert desirable traits into cells and/or organisms. This process is made up of many technologies and is known as recombinant DNA. In order to complete the process, a desired trait must be isolated, removed from its original host, and placed into a new host. The resulting organism or cell is deemed "genetically modified." Ever since the development of such technology, the technology has been subject to the general public's opinion. As a relatively new technology, genetic modification has inadequate data and research completed on it. The genetically modified crops and foods that result possess many potential benefits, yet some fear that the unknown risks may overshadow such benefits.

Background Information: From Then to Now

Humans have altered plants by selective breeding for centuries, involving the work of human actions along with existing natural processes for selection of traits rather than by direct genetic modification. Direct genetic modification, based on a set of technologies that alter genetic make-up by inserting genes rather than using crossbreeding and selection techniques, is a fairly new subject. Known as recombinant DNA technology, direct genetic modification is accomplished by the isolation of a particular gene from one or more organisms to be placed into a different organism. The primary focus of genetic modification is to locate genes that have the ability to produce desired results, such as those conferring insect resistance, reducing sensitivity to herbicides, increasing amounts of desired nutrients, and preventing rotting (Dharmananda).

A genetically modified organism, also known as a transgenic or genetically transformed organism, is created by a set of technologies that make up the general category of genetic modification (McHughen, 2000). Genes can be transferred during selective plant breeding to ensure that the resulting plant has desired traits, but the process of selective breeding must occur over several generations. Genetic engineering has expanded the scope for exchanging of genetic material to produce organisms with desired traits, even traits of unrelated species, in a much shorter time span ("Genetically modified foods," 2010).

Recombinant DNA started in the 1970s, led by American scientists Paul Berg, Stan Cohen, and Herb Boyer (McHughen, 2000). The first reported recombination of genetic material was in 1973; one of the earliest applications was the production of insulin by bacteria, which was approved by the United States Food and Drug Application (FDA) in 1982. In 1988, the first field tests of a genetically modified food plant were undertaken in Canada on a canola plant that would yield a very desirable vegetable oil that was the lowest in saturated fat, high in cholesterol-lowering-mono-unsaturated fat, and the best large-scale plant source of omega-3 fatty acids (Dharmananda). Approximately 167 million acres were devoted to transgenic crops in the year of 2003; currently, 2 billion acres are now devoted to transgenic crops (Dharmananda). Twenty-five countries are currently producing transgenic crops, including: Argentina, Australia, Bolivia, Brazil, Canada, Chile, China, Columbia, Czech Republic, Egypt, Germany, Honduras, India, Mexico, Paraguay, Philippines, Poland, Portugal, Romania, Slovakia, South Africa, Spain, Uruguay, and the United States of America ("Just the Facts," 2010). In 2001, the largest adopter of GM crops were the United States of America (sixty-eight percent), Argentina (twenty-two percent), Canada (six percent), and China (three percent). Despite the debate, GM crop production increased nineteen percent from 2000 to 2001. The major GM crops are soybeans (sixty-three percent), corn (nineteen percent), cotton (thirteen percent), and canola (three percent), with the main desirable traits being herbicide tolerance (seventy-seven percent), insect resistance (fifteen percent), or both (eight percent). Of the total worldwide crop grown in 2001, forty-six percent of soybean crop was biotech, twenty percent of cotton, eleven percent of canola, and seven percent of maize.

Methods of Genetic Modification

Since the initial discovery of enzymes that possessed the ability to either cut DNA molecules at specified sites (restriction enzymes) or join DNA fragments together again (ligases), a wide range of restriction enzymes have been discovered. Using these restriction enzymes, scientists are able to isolate specific genes to later be placed in genetic organisms.

When it comes to transgenic plants, the three primary methods have deemed most successful: *Agrobacterium*, DNA uptake into isolated protoplasts, and the “Gene-Gun” method (Tzotzos, 1995).

The *Agrobacterium* method is mostly used to transform dicotyledonous species. The two principal species used are: *Agrobactierum tumefaciens* and *Agrobacterium rhizogenes*, which in their wild-type form are pathogens causing crown gall disease and hairy-root disease (Tzotzos, 1995). Due to an independently replicating plasmid within in the *Agrobacterium* cell, many dicotyledonous species are highly susceptible to infection by the *Agrobacterium*. By recombinant DNA methods, it has been possible to remove the disease-causing genes. *Agrobacterium* cells carrying the genes of interest are then incubated with cultured cells of the recipient crop plant, and transgenic plants are regenerated from them. It is usually necessary to incorporate selectable marker genes between the t-DNA border sequences since only a small proportion of the treated plant cells become successfully transformed. To select the transgenic plants, the corresponding antibiotic to the marker is added to a plant regeneration medium where only transgenic plants are able to grow normally (Tzotzos, 1995).

Protoplasts are plant cells that have had their cell walls removed by enzymatic treatment, can be produced from various parts of the plant, and are bounded by the plasma membrane, which is a delicate membrane that is easily affected by polethylene glycol treatment or by an electrical current. The DNA to be introduced is added to the medium surrounding the suspended protoplasts, and the chemical or electrical treatment allows the DNA to enter and become incorporated into the cell genome.

The “Gene-Gun” method, which is commonly known as micro-projectile bombardment, is performed in vivo, or within a living organism, and is especially successful in transforming monocot species. DNA is coated onto small particles of gold that are approximately two microns in diameter. Particles are then placed into a vacuum chamber and the plant tissue to be engineered is placed below the chamber. Using a short pulse of high pressure Helium gas, the particles are propelled at high velocity into any target cell or tissue (Keefer).

Dangers of GM Foods

As a relatively new technology, genetic modification has many mysteries and uncharted territories. Risks and methods are yet to be discovered and/or perfected, which leads to lack of precise procedures or adequate data. The process of inserting genes is quite random and can damage normal genes and result in negative side-effects.

Due to the complexity of living organisms, genetic modification poses various dangers. This is because the introduced gene may act differently when working within its new host, the original intelligence of the host is disrupted, and/or the new combination of the host genes and introduced gene(s) may have unpredictable effects. Dangers that have been identified include new toxins and allergens in foods, damaging effects on health caused by unnatural foods, increased use of chemicals on crops that results in increased contamination of water and food supplies, creation of herbicide-resistant weeds, the spread of disease across species barriers, loss of bio-diversity in crops, disturbance of ecological balance, and the passing on of inevitable side-effects of artificially induced characteristics to subsequent generations (Fagan).

Toxins & Allergens

The general public fears being the guinea pig and fears the risk of the creation of new toxins and diseases. The sale of GM foods is being permitted without proper risk assessment or testing. In the current year, allergies are a common ailment. New allergens and toxins can be introduced through the process of genetic engineering. One genetically engineered soybean was found to cause serious allergic reactions, and bacteria genetically engineered to produce large quantities of the food supplement, tryptophan, have produce toxic contaminants that killed thirty-seven people and permanently disabled 1,500 more (Fagan).

Fears of the General Public

The public argues that there is inadequate government regulation and insignificant data available. Biotech companies claim that government regulatory bodies will protect consumers. Recently it was discovered that eighty percent of milk contained traces of harmful medicines, illegal antibiotics used on farms, and/or the genetically engineered bovine growth hormone (rbGH) (Fagan). Ethical concerns are expressed as well. Vegetarians, vegans, and religious groups raise important ethical questions due to the transfer of animal genes into plants (Fagan). Lack of data causes most of the public to remain in the dark. The lack of data is due to the complexity of safety evaluation of crop-derived foods. No peer-reviewed publications of clinical studies on the human health effects of GM food exist. The first and only safety evaluation of a GM crop, the FLAVR SAVR tomato, was commissioned by Calgene, as required by the FDA. This GM tomato was produced by inserting kanR genes, which code for the enzyme neomycin phosphotransferase II, into a tomato. The test has neither been peer-reviewed nor published, but it is on the internet. The results claim that there were no significant alterations in total protein, vitamin, and mineral contents; therefore, the GM tomato and parent tomatoes were deemed to be "substantially equivalent" (Putsztai, 2001).

Benefits of GM Foods

Benefits of GM crops and foods are enhanced taste and quality, reduced maturation time, increased nutrients, yields, and stress tolerance, improved resistance to disease, pests, and herbicides, conservation of soil, water, and energy, better natural waste management, help to smaller farmers, and increased food security for growing populations ("Genetically modified foods," 2008). In the current year, 13.3 million farmers worldwide plant biotech crops that possess beneficial traits, such as resistance to pests, herbicides, and diseases ("Just the facts," 2010).

Pest Resistance

Each year, insects destroy approximately twenty-five percent of food crops worldwide. *Bacillus Thuringiensis*, or Bt, is a bacterium that has attracted much attention for its use in pest control due to its ability to produce a protein that is toxic to various herbivorous insects ("Pest resistant crops," 2006). More than one hundred Bt toxin genes have been cloned and sequenced. In 2001, Bt plant were grow on twelve million hectares. In the case of Bt plants, several types of data are required to provide confidence that no harm will result from the exposure of these proteins. Studies show that the Bt protein behaves as would be expected of a dietary protein, is not structurally related to any known food allergen or protein toxin, and does not display any oral toxicity when administered at high doses. None of the Bt proteins registered as plant pesticides in the United States have shown any significant effect.

> "Genetically modified foods are unlikely to present direct risks to human health" (Nottingham, 1998).

Herbicide Resistance

Perhaps the best known GM food crop is the "RoundUp Ready" soybean, which was developed by Monsanto and introduced in 1997. The soybean allows RoundUp, a herbicide, to get rid of weeds without adversely affecting the soybeans. Currently, eighty-five percent of soybeans in the United States are genetically modified. Another common herbicide resistant GM crop is Liberty Link (Evenson, & Santaniello, 2004). Soy products are widely sold in grocery stores and consumed daily by a majority of the population.

Virus and Disease Resistance

Virus and disease resistance is another trait possessed by GM crops. For example, a sweet potato has been engineered to be resistant to a virus that could decimate most of the African harvest. Bananas have been created that have the ability to resist *Black Sigatoka* and *Fusarium Wilt*. Apples have been engineered to be resistant toward fungal diseases (Apple Scab and Powdery Mildew) and bacterial diseases (Fire Blight).

Other Beneficiary Traits

Along with pest, herbicide, and disease resistance, other GM crops have been engineered with various benefits. Modified oil content and composition for maize, soybeans, rapeseed, and other oil crops could be important in the fight against cardiovascular disease, obesity, and certain forms of cancer. “Golden Rice,” another GM crop, has enhanced levels of beta-carotene and other carotenoids, metabolic precursors of vitamin A. Naturally, rice only contains minimal amounts of beta-carotene, leading to a vitamin A deficiency where rice is a staple food item. “Golden Rice” possesses the potential to alleviate malnourishment in Asian countries. Gluten-free wheat has been engineered to contain higher levels of beneficial antioxidant compounds to prevent cardiovascular diseases and certain forms of cancer.

Fruits and vegetables, such as FLAVR SAVR tomatoes, apples, raspberries, melons, green peppers, and onions are modified to stay fresh longer ("Food and nutrition," 2010). Crops are being engineered to survive in extreme weather conditions and have increased yields. For example, in the 1960s, the amount of available rennet, an enzyme preparation used to produce cheese, did not match with the growing demand for cheese. Traditionally isolated from the lining of calf stomachs, rennet contains chymosin, which causes milk protein (casein) to clump and form hard cheese. Bacteria were then modified by inserting a gene that codes for producing chymosin identical to a calf. In 1981, a technology succeeded; seven years later, chymosin was the first enzyme from a genetically modified source to gain approval for use in food (Putsztai, 2001). These traits help to provide confidence in an adequately sized food supply for a growing population.

Conclusion

Genetically modified foods have been created to benefit the human population. In a survey completed by fellow peers, it was discovered that seventy percent of people were in favor of genetically modified foods and felt that the benefits outweighed all of the risks. Being a relatively new technology, it will take time to reassure all of the general public. Media wants to uncover stories of failures; failures are necessary in order to reach perfection. Increased yield, nutrition, resistance to pests, herbicides, diseases, and conservation of water, soil, and energy are only a few of the plethora of benefits that are offered by genetically modified foods. The main fear is the unknown; the public does not want to be the guinea pig for biotech companies while they perfect their GM crops and foods. In time, adequate testing and data will be acquired that will instill a sense of confidence into the public. Genetic modification has been done for years and years; now, humans are using their intelligence and power to control their future.

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