Script

Genetically Modified Foods (GM Foods)

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1. Introduction

A genetically modified (GM) food 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. The GM foods also referred to as biotech foods, gene foods, bioengineered foods, gene-altered foods, transgenic foods, and foods that have been created through genetic engineering. GM foods are foods produced from organisms (plants or animals) which have had specific changes introduced into their DNA using one of the methods of genetic engineering. GM has been used in a variety of ways to assist food manufacturing and to improve factors such as storage or nutritional value of food. Many processed foods contain GM ingredients. GM foods differ from non-GM (conventional) foods, in that they contain or are produced from a GMO or they contain GM ingredients.

The term GM foods is most commonly used to refer to crop plants created for human or animal consumption using the latest molecular biology techniques. These plants have been modified in the laboratory to enhance desired traits such as increased resistance to herbicides or improved nutritional content. 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 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.

GM foods are developed – and marketed – because there is some perceived advantage either to the producer or consumer of these foods. This is meant to translate into a product with a lower price, greater benefit (in terms of durability or nutritional value) or both. Initially GM seed developers wanted their products to be accepted by producers and have concentrated on innovations that bring direct benefit to farmers (and the food industry generally).

The majority of plants targeted for development as GM foods are the traditional plants (maize, canola, wheat, soya, peas, etc.) that have had their traits selected upon for thousands of years. Transgene GM foods have as their main innovations the prospect of boosting or modifying existing traits in foods (e.g., higher protein content in grains; pesticide/herbicide resistance) or

adding traits not traditionally found in a particular plant (e.g., beta-carotene in rice, herbicide resistance).

With regard to the chronological sequence of GM foods/crops development and introduction into the market, they are categorized as first-, second-, and third-generation GM foods/crops. Some of the specific characteristics of the first-generation GM foods/crops include improved pest and disease control, abiotic stress tolerance, herbicide tolerance, and increased crop yield. These characteristics are also referred to as “input characteristics”. Characteristics of second-generation GM crops, also known as “output characteristics,” define some desirable quality attributes such as improved nutritional profiles leading to functional foods, increased postharvest life, and enhanced processing qualities. The third-generation GM crops, also called “plants as factories”, are characterized by their suitability for novel uses such as plant-based pharmaceuticals and plant-made industrial products.

The majority of current plant biotechnology is directed towards the improvement of food plants; the remaining work is concerned with non-food crops such as cotton, tobacco, ornamental plants and pharmaceuticals. The initial emphasis has generally been on the improvement of qualities of value to the farmer. Most of this work has been initiated and funded by the seed industry. The second and third generations of genetically-modified food plants will bring benefits that more directly affect commercial food processors and consumers. Many thousands of field trials of genetically-modified plants have been carried out world-wide.

2. Need of GM Foods

The world population has topped 6.5 billion people and is predicted to double in the next 50 years. Ensuring an adequate food supply for this booming population is going to be a major challenge in the years to come. GM foods promise to meet this need in a number of ways:

- **Nutrition**: Malnutrition is common in third world countries where impoverished people rely on a single crop such as rice for the main staple of their diet. However, rice does not contain adequate amounts of all necessary nutrients to prevent malnutrition. If rice could be genetically engineered to contain additional vitamins and minerals, nutrient deficiencies could be alleviated. For example, blindness due to vitamin A deficiency is a common problem in third world countries. Researchers at the Swiss Federal Institute of Technology Institute for Plant Sciences have created a strain of "golden" rice containing an unusually high content of beta-carotene (vitamin A).
- **Pest resistance:** Crop losses from insect pests can be staggering, resulting in devastating financial loss for farmers and starvation in developing countries. Farmers typically use many tons of chemical pesticides annually. Consumers do not wish to eat food that has been treated with pesticides because of potential health hazards, and run-off of agricultural wastes from excessive use of pesticides and fertilizers can poison the water supply and cause harm to the environment. Growing GM foods can help eliminate the application of chemical pesticides and reduce the cost of bringing a crop to market.

- **Herbicide tolerance:** For some crops, it is not cost-effective to remove weeds by physical means such as tilling, so farmers will often spray large quantities of different herbicides (weed-killer) to destroy weeds, a time-consuming and expensive process, that

requires care so that the herbicide doesn't harm the crop plant or the environment. Crop plants genetically-engineered to be resistant to one very powerful herbicide could help prevent environmental damage by reducing the amount of herbicides needed.

- **Disease resistance:** There are many viruses, fungi and bacteria that cause plant diseases. Plant biologists are working to create plants with genetically-engineered resistance to these diseases.

- **Cold tolerance**: Unexpected frost can destroy sensitive seedlings. An antifreeze gene from cold water fish has been introduced into plants such as potato. With this antifreeze gene, these plants are able to tolerate cold temperatures that normally would kill unmodified seedlings.

- **Drought tolerance/salinity tolerance**: As the world population grows and more land is utilized for housing instead of food production, farmers will need to grow crops in locations previously unsuited for plant cultivation. Creating plants that can withstand long periods of drought or high salt content in soil and groundwater will help people to grow crops in formerly inhospitable places.

- Pharmaceuticals Medicines and vaccines often are costly to produce and sometimes require special storage conditions not readily available in third world countries. Researchers are working to develop edible vaccines in tomatoes and potatoes. These vaccines will be much easier to ship, store and administer than traditional injectable vaccines.

3. GM food crops

Some foods and fibre crops have been modified to make them resistant to insects and viruses and more able to tolerate herbicides. The major crops that have been modified for these purposes, with approval from the relevant authorities, are:

Apples. One of the problems encountered with apples (in addition to other plant products, e.g., potato) is browning when cut and exposed to air. In the year 2012, an apple variety has been genetically modified to resist this type of browning. The gene responsible for the production of the enzyme polyphenol oxidase which helps the browning process has been modified in such a way that less amounts of the enzyme are produced in the apple. This modified apple variety is known as “nonbrowning Arctic apple” and has been produced by “Okanagan Speciality Fruits”.

Corn (Maize). GM corn has been developed through introducing a gene from a soil bacteria (*Bacillus thuringeinsis*) which is able to produce a toxin that acts as a pesticide and kills certain insects. The GM corn is known as Bt corn as related to the bacteria donating the gene and it is rendered pest-resistant. Different products are obtained from this GM corn, for example, grits, meal, and corn flour, corn oil, sugar, and syrup. Grits are the coarsest products resulting from corn dry milling. They are generally used to produce breakfast cereals and snack foods. Corn meal is used in the production of cornbread, muffins, fritters, bakery mixes, and pancake mixes. Corn flour is the finest product of the corn dry-milling process. It is usually used to produce

pancake mixes, muffins, doughnuts, breadings, and batters in addition to baby foods, meat products, and some fermented foods. These products are consequently used to process foods like snack foods, baked goods, fried foods, edible oil products, confectionery special purpose foods, and soft drinks.

Papaya. GM papayas have been developed to resist the ringspot virus. The first virus-resistant papayas were produced in Hawaii in 1999. Before this, the Hawaii's papaya industry was threatened by the deadly ringspot virus. The development of a virus-resistant papaya crop helped to address the problem.

Peas. GM peas developed by inserting a gene from kidney beans, which creates a protein that acts as a pesticide, have shown possible allergens in mice. This observation suggested that the same allergic reaction may happen to people consuming these GM peas. Due to this, it has not been released to the market.

Potato. At present, there are no transgenic potatoes marketed for human consumption. This followed the development of the "New Leaf Potato" by Monsanto in the late 1990s, which targeted the fast food market. It was eventually withdrawn from the market in 2001 after it failed to pick up in the retail market. This has not stopped efforts to develop GE potato with different desired traits, for example, resistance to late blight disease, bruise prevention, and production of less acrylamide during frying.

Rice. Naturally, rice is deficient in vitamin A or its precursor beta carotene. On the other hand, rice constitutes the staple food for a high percentage of world population particularly in developing regions. Vitamin A deficiency has been a chronic problem for people in developing countries, especially affecting women and children. One approach sought as a solution to this problem is the development of rice which contains beta carotene. A transgenic strain of rice known as "Golden Rice" has been engineered. It contains beta carotene that would be converted into vitamin A when consumed by humans. Another development reported for GM rice is a variety containing human genes not targeted for human consumption but for human treatment of infant diarrhea, particularly in the developing world.

Soybean. GE soybean (Roundup Ready Soybean) has been developed by Monsanto to be resistant to the Roundup WeatherMAX herbicide which could be sprayed to kill weeds with no harm on the soy plant itself. Products obtained from soy include soybean oil, soy flour, soy protein concentrate, soy protein isolate, lecithin, and textured soy protein. Soybean-based foods include soy milk and other soy beverages, tofu, breads, pastries, snack foods, baked or fried foods, and special purpose foods.

Sugar Cane. Some sugar cane cultivars have been genetically modified for pesticide resistance. GM sugar cane has not met the expected success in the market due to the low level of acceptance by consumers.

Tomato. The first commercially grown GM whole food crop was tomato. In 1994, Calgene, a biotechnology company from California, USA, genetically engineered a tomato variety named "FlavrSavr." This pioneer transgenic crop was modified to ripen without softening and attain a longer shelf life by delaying its natural tendency to rot and degrade quickly. It was welcomed by

consumers who purchased the fruit at a substantial premium over the price of regular tomatoes. In 1997 and due to economic difficulties, Calgene was forced to withdraw the FlavrSavr tomato from the grocery shelves. In spite of these problems, research for new modifications on tomato continued. In 2001, research scientists announced research results for the development of salt-resistant tomato. This would help to utilize areas with high salt content which are otherwise uncultivable with other crops. It also helps to lower salt content of those soils.

4. GM food products

It might be impractical to come up with a full list that includes all genetically modified foods/products produced worldwide. This is because there are no regulations guiding labeling of GM foods in the United States, the major producer of GM foods globally. Butcher (2003) reports that some estimates say as many as 30,000 different food products on grocery stores shelves are modified. However, in this section we will study only the common GM Food products.

- *Chymosin.* Microorganisms have been modified genetically to yield chymosin that is identical to the enzyme obtained from animals. This can be used to produce better-quality cheese than the fungal or other animal (non-calf) rennets. In 1988, chymosin was the first enzyme from a genetically-modified source to gain approval for use in food. Three such enzymes are now approved in most European countries and the USA. Chymosin obtained from recombinant organisms has been subjected to rigorous tests to ensure its purity. Today about 90% of the hard cheese in the UK is made using chymosin from genetically-modified microbes.
- Baking yeast**:** In 1990 the United Kingdom became the first country to permit the use of a live, genetically-modified organism in food. This was a special strain of bakers' yeast engineered to make the bread dough rise faster. Existing genes were placed under the control of stronger, constitutive promoters, which help the yeast to break down the sugar maltose faster than usual.
- Brewers' yeast. It is now over 20 years since the first research on the genetic modification of brewing yeasts, and many modified strains have been developed. However, no brewers in the world currently use genetically-modified yeasts. Only one modified yeast, produced by John Hammond and his colleagues at the Brewing Research Foundation International (a UK research organisation), has received approval for use in beer production.
- Tomato Puree. In February 1996, the United Kingdom introduced Europe's first genetically-modified food product. This GM product was prepared by using the raw tomato products, which are produced by the process of GM tomatoes. This produced by the British firm Zeneca Seeds (subsequently part of Syngenta).

- *Canola (Oil).* Herbicide (Roundup)-resistant cultivars of rapeseed were produced by Monsanto. Rapeseed is cultivated mainly for edible oil production, which is regarded as the third largest source of vegetable oil in the world. The oil is used in various edible oil products including fried foods, baked products, and snacks. In Canada, where “double zero” rapeseed was developed, the crop was given the name “canola” (Canadian oil).

- *Cotton (Seed Oil).* Bt cotton is GM cotton used in the same way as Bt corn, consequently making it pest-resistant. Cotton seed oil is extracted from cotton seeds and is used as an edible oil to cook, fry, or bake foods. It is also incorporated in snack foods and is blended with other edible oils.

- *Honey*. Honey can be produced from flowers of GM crops. In Canada, some types of honey are produced by bees collecting nectar from GM canola plants. Some European countries do not allow imports of honey produced from GM crops, thus the ban of this type of Canadian honey.

5. The risks of GM foods

Environmental activists, religious organizations, public interest groups, professional associations and other scientists and government officials have all raised concerns about GM foods, and criticized agribusiness for pursuing profit without concern for potential hazards, and the government for failing to exercise adequate regulatory oversight. Most concerns about GM foods fall into three categories: environmental hazards, human health risks, and economic concerns.

Environmental hazards

- Unintended harm to other organisms. A laboratory study was published in *Nature* showing that pollen from Bt corn caused high mortality rates in monarch butterfly caterpillars.

- Reduced effectiveness of pesticides. Just as some populations of mosquitoes developed resistance to the now-banned pesticide DDT, many people are concerned that insects will become resistant to Bt or other crops that have been genetically modified to produce their own pesticides.

- Gene transfer to non-target species. Another concern is that crop plants engineered for herbicide tolerance and weeds will cross-breed, resulting in the transfer of the herbicide resistance genes from the crops into the weeds. These "superweeds" would then be herbicide tolerant as well. Other introduced genes may cross over into non modified crops planted next to GM crops.

Human health risks

- Allergenicity. Many children in the US and Europe have developed life-threatening allergies to peanuts and other foods. There is a possibility that introducing a gene into a plant may create a new allergen or cause an allergic reaction in susceptible individuals.

- Unknown effects on human health. There is a growing concern that introducing foreign genes into food plants may have an unexpected and negative impact on human health. A recent article published in Lancet examined the effects of GM potatoes on the digestive tract in rats. This study claimed that there were appreciable differences in the intestines of rats fed GM potatoes and rats fed unmodified potatoes.

Economic concerns

Bringing a GM food to market is a lengthy and costly process, and of course agri-biotech companies wish to ensure a profitable return on their investment. Many new plant genetic engineering technologies and GM plants have been patented, and patent infringement is a big concern of agribusiness. Yet consumer advocates are worried that patenting these new plant varieties will raise the price of seeds so high that small farmers and third world countries will not be able to afford seeds for GM crops, thus widening the gap between the wealthy and the poor.

Conclusion: Genetically-modified foods have the potential to solve many of the world's hunger and malnutrition problems, and to help protect and preserve the environment by increasing yield and reducing reliance upon chemical pesticides and herbicides. Yet there are many challenges ahead for governments, especially in the areas of safety testing, regulation, international policy and food labeling.