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A Review Of The Health Implications Of Genetically Modified Foods

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--ABSTRACT--

Genetic modifications offer a variety of potential benefits and risks. It has enhanced food production by making plants less vulnerable to drought, frost, insects, and viruses and by enabling plants to compete more effectively against weeds for soil nutrients. In a few cases, it has also improved the quality and nutrition of foods by altering their composition. However, the use of biotechnology has also raised concerns about its potential risks to the environment and consumers. Genetic engineering provides a means to introduce genes into plants via mechanisms that are different in some respects from classical breeding. A number of commercialized, genetically engineered (GE) varieties, most notably tomato, cotton, maize and soybean, were created using this technology, and at present the traits introduced are herbicide pest tolerance. Gene technology enables the increase of production in plants, as well as the rise of resistance to pests, viruses, frost, etc. Gene transfer is used to modify the physical and chemical composition and nutritional value of food. Gene transfer in animals will play a part in boundless possibilities of improving qualitative and quantitative traits. The yield, carcass composition and meat characteristics the use of nutritive substances and resistance to diseases can be improved. On the other hand, negative effects of gene technology on animals, human, and environment should be considered.

KEYWORDS: *Genetic engineering, genetically modified foods, health hazard.*

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I. INTRODUCTION

Genetic engineering is the changing of inherent features by altering structures or positions of individual genes [1]. Genetic engineering can be done with plants, animals, or microorganisms. Selective breeding over time created these wide variations, but the process is dependent on nature to produce the desired gene. Humans then chose to mate individual animals or plants that carried the particular gene in order to make the desired characteristics more common or more pronounced. Genetic engineering allows scientists to speed this process up by moving desired genes from one plant into another or even from an animal to a plant or vice versa [2].However, the term “genetic modification” actually covers a broad range of processing, from basic selective breeding and hybridization, right through to recombinant DNA technology, also known as “gene splicing” [3]. Genetically modified organisms (GMOs) are defined as organisms (except for human beings) in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination [4]. GMOs have widespread applications as they are used in biological and medical research, production of pharmaceutical drugs, experimental medicine, and agriculture. Genetic modification is possible only because the genes of all organisms (except some viruses) are made of the same chemical deoxyribonucleic acid (DNA). This basic similarity allows the DNA from two different organisms to be put or spliced together. Once the recombined or spliced DNA is introduces into another organism, it “permanently changes the genetic make-up of that organism and all its descendants [3].

The first genetically modified food to reach the worlds market was the Flavr Savr tomato. Grown in California, the Flavr Savr tomato received Food and Drug Administration approval in 1994, after two years of testing and assessment. Mounting costs made the crop unprofitable and its production ceased in 1997. Creation of the Flavr Savr opened the doors for other GM foods to make their way into the market [5]. Recently, genetically modified foods have gained its ground in the food industries worldwide. Various researches indicated a successful application of genetically modification in enhancing many agricultural food products including; tomatoes, sweet maize, carrots, rape plants, golden rice and soybeans.

Animals can also be genetically modified. Scientists are researching the genetic modification of fish, cows and pigs amongst others. Currently there are no genetically modified meat products on the market [6].Owing to this good trait, genetically modified food products may inflict harm to the human health or impose hazards to the environment. Some of the health hazards associated with GM foods are; death, food allergies, cancer and degenerative diseases, super-viruses, antibiotics threats, unnatural foods, and extinctions of natural foods. This has led to GM food controversies, involving the consumers, biotechnology companies, governmental regulators, non-governmental organizations and scientists.The objectives of this study is to review the health implications of genetically modified foods, the manipulations, applications, science involved, controversies and the possible control measures for these effects.

II. SCIENCE OF GENETIC MODIFICATION

The fundamental components of all genetic modification are the genes. A gene is the unit of hereditary in a chromosome, controlling a particular inherited characteristic of individual living organisms [7]. Genetic modification is possible only because the genes of all organisms (except some viruses) are made of the same chemical known as DNA, or deoxyribonucleic acid. The DNA chemical plays a central role in protein synthesis which is a fundamental building substance of living organisms with identical set of genes of which some are active while others are inactive. In other words, some genes are "switched on" while others are switched off. The process of gene activation is still obscure. However, it is believed that near each gene is a sequent of DNA known as the "promoter". This is the site at which "Transcription" begins. Transcription is the production of a strand of MRNA, or messenger ribonucleic acid. MRNA is a chemical, which carries information for the synthesis of one or more protein. Hence, the promoter is responsible for activating gene or switched it on [8].

The new techniques resulting from genetic modification differ from selective breeding practices in at least two significant ways. DNA technology has enabled the so-called "wide transfer" of genes between unrelated species. In the application of biotechnology to agricultural crops, the United Nations Food and Agriculture Organization (FAO) recognize three distinct types of genetic modifications these are:

- Wide Transfer: Where genes are transferred from organisms of other kingdom (e.g. bacteria, animal) into plants.
- Close Transfer: Where genes are transferred from one species of plant to another.
- Tweaking: Where genes already present in the plant's genome are manipulated to change the level or pattern of expression.

2.1 Genetically modified agricultural food products

The term GM foods or GMOs (genetically-modified organisms) is most commonly used to refer to crop plants created for human or animal consumption using the latest molecular biology techniques [9]. These plants have been modified in the laboratory to enhance desired traits such as increased resistance to herbicides or improved nutritional content. The enhancement of desired traits has traditionally been undertaken through breeding, but conventional plant breeding methods can be very time consuming and are often not very accurate. Genetic engineering, on the other hand, can create plants with the exact desired trait very rapidly and with great accuracy [10]. For example, plant geneticists can isolate a gene responsible for drought tolerance and insert that gene into a different plant. The new genetically-modified plant will gain drought tolerance as well. Not only can genes be transferred from one plant to another, but genes from non-plant organisms also can be used. The best known example of this is the use of *Bacillus thuringiensis* (B.t.) genes in corn and other crops. B.t. is a naturally occurring bacterium that produces crystal proteins that are lethal to insect larvae. B.t. crystal protein genes have been transferred into corn, enabling the corn to produce its own pesticides against insects such as the European corn borer [1, 11].

Genetically modifying foods or food crops can enhance taste and quality, increase nutrients or improve resistance to pests and disease. In some cases, GM foods help conserve natural resources, because the altered version might require less water or energy for processing. Some genetically modified foods that have gained its ground in the food industries include the following [12, 13]:

1. **SUGAR BEETS:** Modified to improve production.
2. **POTATOES:** Modified with cholera antibody vaccine.
3. **CORN:** Bt-corn (named after the *Bacillus thruringiensis* bacterium) is a form of sweet corn that has been genetically modified to include an insect-killing gene.
4. **TOMATO:** altered for only one reason: to make them last longer.
5. **GOLDEN RICE:** Created to fight vitamin A deficiency.
6. **SOYBEAN:** Modified to increase production and resistance to herbicides.

7. **SQUASHES:** Squash is more prone than some crops to viral diseases, which is why it was genetically modified to ensure crop survival.
8. **ANIMAL FEED:** A large percentage of animal feed is made up of crops such as soybeans. This means the chances of livestock eating GM feed is very high, no matter where in the world. Animal feed is commonly enhanced with vitamins, amino acids, enzymes and even coloring.
9. **OILS:** Modification of Canola or rapeseed oil did away with the bitter taste and also increased rapeseed's resistance to herbicides.
10. **SALMON FISH:** Modified to grow fast and reach about twice the size of its wild variety.
11. **TANGELO:** Combined genetic splicing of the genes of Tangerine and grapefruit. It boasts a ton of fiber, vitamin C, and a slightly tart taste.
12. **LEMATOES:** Combined genes of lemon and tomatoes.

III. ADVANTAGES OF GM FOODS

1. Pest resistance:

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. Also 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 such as B.t. corn can help to eliminate the application of chemical pesticides and reduce the cost of bringing a crop to market [14].

2. Herbicide tolerance:

Crop plants genetically-engineered to be resistant to one very powerful herbicide could help to prevent environmental damage by reducing the amount of herbicides needed. For example, Monsanto has created a strain of soybeans genetically modified to be not affected by their herbicide product Roundup. A 2010 study has found that long-term exposition to environmental relevant concentrations of a Roundup formulation causes metabolic disruption in *Leporinus obtusidens*. A farmer grows these soybeans which then only require one application of weed-killer instead of multiple applications, reducing production cost and limiting the dangers of agricultural waste run-off [15].

3. 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 [10].

4. Cold tolerance:

An antifreeze gene from cold water fish has been introduced into plants such as tobacco and potato. With this antifreeze gene, these plants are able to tolerate cold temperatures that normally would kill unmodified seedlings [10, 15].

5. 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 [16].

6. 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 amount 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 a vitamin A deficiency is a common problem in third world countries. Researchers at the Swiss Federal Institute of Technology for Plant Science have created a strain of “golden” rice containing an unusually high content of beta-carotene (vitamin A). Plans were underway to develop golden rice that also has increased iron content [14].

7. Pharmaceuticals:

Medicines and vaccines often are costly to produce and sometimes require special storage conditions. 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 [12].

8. Phytoremediation:

Plants such as poplar trees have been genetically engineered to clean up heavy metal pollution from contaminated soil [13].

IV. HEALTH IMPLICATIONS OF GENETICALLY MODIFIED FOODS

The genetic engineering of food has played a positive role to the society since its invention although findings indicated more hazards are associated with it, ranging from health, environmental, socioeconomic down to ethical.

Some of these hazards are:

i. Toxin and Poisons: Genetically engineered products clearly have the potential to be toxic and a threat to human health. In 1989, a genetically manufactured brand of L-triptophan, a common dietary supplement, killed 37 Americans and permanently disabled more than 5,000 others with a potentially fatal and painful blood disorder. [17].

ii. Increased Cancer Risks: Genetically engineered recombinant Bovine growth Hormone (RBGH) has shown to have damage to laboratory rats fed dosages of RBGH and it indicates potential cancer hazards to the prostate of the rat. Again higher levels of a potential chemical hormone, insulin-like growth (IGF-1), in milk and dairy products of injected cows could pose serious hazards for human breast, prostate and colon cancer [18].

iii. Food allergies: In 1996 a major genetically engineered (GE) food disaster was narrowly averted when Nebraska researcher learned that a Brazil nut gene spliced into soybeans could produce potentially fatal allergies (which currently afflicted 8% of all American children) whose symptoms range from mild unpleasantness to sudden death. Some individuals, however, are so allergic to this nut; they can go into anaphylactic shock (similar to a severe bee sting reaction) which can cause death. Using genetic engineering, the allergens from one food can thus be transferred to another, thought to be safe to eat, and unknowingly**.** Animal and human tests confirmed the peril and fortunately the product was removed from the market before any fatalities occurred. The animal tests conducted, however, were insufficient by themselves to show this **[16].**

iv. Damage to Food Quality and Nutrition: Findings has shown that the concentration of beneficial phytoestrogen compounds though to protect against heart disease and cancer were lower in genetically modified soybeans than in traditional strains. These and other studies, including Dr. Pusztail indicate that genetically engineering food will likely result in food lower in quality and nutrition for example, the milk from cows injected with EBGH contains higher levels of pus, bacteria and fat [12, 16].

v. Genetic Pollution: Genetic pollution and collateral damage from GE field crops already have begun to wreak environmental havoc. Wind, air rain, birds, bees and insects polluters have begun carrying genetically altered pollen into adjoining field, polluting the DNA of crops organic and non GE farmers [11].

Other shortlisted health implications of GM foods are [17, 4, 7]:

vi. Antibiotic Threat through Milk.
vii. Antibiotic Threat through Plants.
viii. Damage to Beneficial Insects and Soil Fertility.
ix. Lowered Nutrition.
x. Unnatural Foods.
xi. Extinction of Seed Varieties.
xii. Impact on Long -Term Food Supply.
xiii. Super-weeds.
xiv. Gene transfer to non target species.
xv. Indirect, Non-Traceable Effects on Cancer Rates.
xvi. Increased Pesticide Residues in the Soil and in Crops.
xvii. Creation of New Viruses and Bacteria.
xviii. Super-viruses.
xix. Birth Defects and Shorter Life Spans.
xx. Resurgence of Infectious Diseases.
xxi. Health/Environmental/Socio-Political Reasons.

4.1 Roles of government in regulating GM foods

The genetically modified foods controversy is a dispute over the relative advantages and disadvantages of food derived from genetically modified organisms, genetically modified crops used to produce food and other goods, and other uses of genetically modified organisms in food production. The dispute involves consumers, biotechnology companies, governmental regulators, non-governmental organizations and scientists [18, 19]. Governments around the world are hard at work to establish a regulatory process to monitor the effects of and approve new varieties of GM plants. Regulatory agencies such as the Food and Drugs Act (FDA), Environmental Protection Aagency (EPA), United States Department of Agriculture (USDA), and the Ministry of Health and Welfare all have jurisdiction over GM foods to ensure all GM foods are safe and conform to standards and specification, and at the same time dealing with the controversies surrounding GM food products.
In the United States, the regulatory process is confused because there are three different government agencies that have jurisdiction over GM foods. To put it very simply, the EPA evaluates GM plants for environmental safety, the USDA evaluates whether the plant is safe to grow, and the FDA evaluates whether the plant is safe to eat. The EPA is responsible for regulating substances such as pesticides or toxins that may cause harm to the environment. GM crops such as B.t. pesticide-laced corn or herbicide-tolerant crops but not foods modified for their nutritional value fall under the purview of the EPA. The USDA is responsible for GM crops that do not fall under the umbrella of the EPA such as drought-tolerant or disease-tolerant crops, crops grown for animal feeds, or whole fruits, vegetables and grains for human consumption. The FDA historically has been concerned with pharmaceuticals, cosmetics and food products and additives, not whole foods. Under current guidelines, a genetically-modified ear of corn sold at a produce stand is not regulated by the FDA because it is a whole food, but a box of cornflakes is regulated because it is a food product. The FDA's stance is that GM foods are substantially equivalent to unmodified, "natural" foods, and therefore not subject to FDA regulation [20, 21].

4.2 Possible solutions and recommendation for gm food problems

Labeling of GM foods and food products is an important issue. On the whole, agribusiness industries believe that labeling should be voluntary and influenced by the demands of the free market. If consumers show preference for labeled foods over non-labeled foods, then industry will have the incentive to regulate itself or risk alienating the customer [21, 18].There are many questions that must be answered if labeling of GM foods becomes mandatory. First, consumers pocket; are consumers willing to absorb the cost of such an initiative? If the food production industry is required to label GM foods, factories will need to construct two separate processing streams and monitor the production lines accordingly. Farmers must be able to keep GM crops and non-GM crops from mixing during planting, harvesting and shipping. It is almost assured that industry will pass along these additional costs to consumers in the form of higher prices. Secondly, acceptable limit of contamination; what are the acceptable limits of GM contamination in non-GM products? The EC has determined that 1% is an acceptable limit of cross-contamination, yet many consumer interest groups argue that only 0% is acceptable. The FDA should have the resources to carry out testing to ensure compliance.

Proper analysis on GM foods; what is the level of detection of GM food cross-contamination? Scientists agree that current technology is unable to detect minute quantities of contamination, so ensuring 0% contamination using existing methodologies is not guaranteed. Yet researchers disagree on what level of contamination really is detectable, especially in highly processed food products such as vegetable oils or breakfast cereals where the vegetables used to make these products have been pooled from many different sources. A 1% threshold may already be below current levels of detection [12].Finally, public enlightenment campaign; considering who is to be responsible for educating the public about GM food labels and how costly will that education be? Food labels must be designed to clearly convey accurate information about the product in simple language that everyone can understand. This may be the greatest challenge faced be a new food labeling policy: how to educate and inform the public without damaging the public trust and causing alarm or fear of GM food products [13].In addition to labeling, another possible solution is the creation of GM plants that are male sterile or pollen free from the modified gene.

Conclusion and recommendation

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.

Genetically modified organism (GMOs) should be carefully researched and monitored to ensure lesser hazards to users and the environment. In addition, concerted action should be undertaken to ensure that necessary consideration is given to the ethical and social effects of such studies.
Mandatory labeling is recommended for GM foods, since consumers have the right to know what they are eating, and labeling is the major way to differentiate GM foods from selective cross breeding and other foods. GM foods are generally regarded as safe, provided it meets up to the standards and specifications of regulatory agencies. Hence people should be encouraged to eat GM foods.

Further studies are recommended on the effect of GM crops on the environment, the impact of GM crops for farmers, including farmers in developing countries, the role of GM crops in feeding the growing world population, and GM crops as part of the industrial agriculture system.

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