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The Health Effects of Genetically Modified Foods: a Brief Review

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Abstract

Genetically modified foods are organisms (i.e. plants or animals) in which the genetic material (Deoxyribonucleic Acid) has been altered in a way that does not occur naturally by mating and/or natural recombination. Combining genes from different organisms is known as recombinant Deoxyribonucleic Acid technology and the resulting organism is said to be 'Genetically Modified', 'Genetically Engineered' or 'Transgenic'. Crops grown commercially and/or field-tested are resistant to a virus that could destroy most of the African harvest, other crops with increased iron and vitamins that may alleviate chronic malnutrition and a variety of plants that are able to survive weather extremes. There are fruits that produce human vaccines against infectious diseases such as hepatitis B, fish that mature more quickly, fruit and nut trees that yield years earlier and plants that produce new plastics with unique properties. Controversies and public concern surrounding Genetically Modified foods and crops commonly focus on human and environmental safety, ethics, food security, poverty reduction and environmental conservation. With this new technology on gene manipulation there are the risks of tampering with nature, effects will have on the environment, the health concerns that consumers should be aware of, and effects related with recombinant technology. This review addresses the major concerns about the safety, environmental and legal issues which are collectively infer health hazards of Genetically Modified foods and recombinant technology in different perspective.

Keywords: Genetically modified food; Genetic engineering; Transgenic; Alergenicity; Recombinant technology

Introduction

Food is one of the most important necessities for humans; we eat to live and at least most people are blesses with a meal a day, while some others can afford three or more. Independent of our culture and customs, dinning remains a vital aspect in different festivities across the world between and within families and friends. Furthermore, we want a healthy and nutritious meal but the question is "How safe is the food we are consuming?"

The improvement of plants and livestock for food production and the use of different conservation techniques have been in practice as long as humankind stopped migrating relying on agriculture for survival. With the quest to grow more and better food to meet the demand of our fast growing world population, genetic engineering of crops has become a new platform in addition to plant breeding [1].

The health risk assessments are often, but not always, based on the study of blood analyses of mammals eating these products in sub-chronic tests, and more rarely in chronic tests. Genetically Modified Food (GMF) means any food containing or derived from a genetically engineered organism. The majority of the biotech-crops available on the global market have been genetically manipulated to express one of these basic traits: resistance to insects or viruses, tolerance to certain herbicides and nutritionally enhanced quality [2].

Genes change every day by natural mutation and recombination, creating new biological variations. Humans have been exploiting this for centuries shuffling genes in increasingly systematic ways and using extensive crossing and artificial selection to create many combinations that would never otherwise have occurred. Just about everything we eat is derived from livestock, crops, and micro-organisms bred specifically to provide food. Humans have also redistributed genes geographically: the soybean is native to Asia but is now grown throughout the Americas, and the potato, native to the American continent, is grown throughout the temperate world. DNA has never been "static," neither naturally nor at the hand of people [3].

In 1946, scientists first discovered that DNA can be transferred between organisms. Genetic modification is an extension of this. Combining genes from different organisms is known as recombinant DNA technology and the resulting organism is said to be 'Genetically Modified (GM)', 'Genetically engineered' or 'Transgenic'. Genetically Modified Organisms (GMOs) are plants, animals or microorganisms that have had their genetic material altered in the lab to create new varieties of plants, animals, and organisms with desired characteristics. GM products which are currently in the pipeline include medicines and vaccines, foods and food ingredients, feeds and fibers.

It is now known that there are several mechanisms for DNA transfer and that these occur in nature on a large scale, for example, it is a major mechanism for antibiotic resistance in pathogenic bacteria. However, unlike conventional breeding, in which new assortments of genes are created more or less at random, genetic modification

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allows specific genes to be identified, isolated, copied, and introduced into other organisms in much more direct and controlled ways. The principal transgenic crops grown commercially in field are herbicide and insecticide resistant soybeans, corn, cotton and canola. Other crops grown commercially and/or field-tested are sweet potato resistant to a virus that could destroy most of the African harvest, rice with increased iron and vitamins that may alleviate chronic malnutrition in Asian countries and a variety of plants that are able to survive weather extremes. There are bananas that produce human vaccines against infectious diseases such as hepatitis B, fish that mature more quickly, fruit and nut trees [4]. This literature review thus primarily assess the literatures which shows the positive or/and negative health effects of genetically modified foods on human beings and their life.

Objective: To review the effect of genetically modified food on health.

Materials and Methods

Published articles and books were searched in Google Scholar. The search strategy was employed using a combination of keywords and Boolean functions; "Genetically modified foods" OR "genetically engineered foods" OR "health effect of GMF" OR "impacts of GMF". Then, the searched documents were compiled together and screened for duplication. Finally, reference lists cited by each eligible study were assessed to identify additional articles. Before starting data extraction, selection process of the relevant studies was explained under the characteristics of included studies using texts and graphical presentation. After data extraction, the findings were grouped together into two thematic areas 'Positive Effect and Negative Effects'. Finally, data were presented using texts.

Results

This literature review was conducted on published studies which were conducted all over the globe. An online electronic search was done using Google Scholar, and we identified a lot of articles from which some data files were removed due to duplication while others also excluded due to short communication and lack of relevant data with respect to this review. Finally major findings on those literature are extracted and put here as a results which are then discussed in later part of this review.

Effects of GM foods on health

Like any new technology, the agricultural biotechnology poses benefits and risks. Various economic, environmental, social, ethical, and political issues must be considered. Population increases, especially in developing countries, create the need for an ever-larger food supply. Many observers have suggested that biotechnology has the potential to increase world food output and reduce food insecurity by improving crop yields and reducing crop loss. As with any improvement in technology, farmers in developing countries must find the new advances profitable. Consumers in developing countries will benefit if biotech crops are less expensive or more nutritious than traditional crops. Researchers look for genes that will benefit the farmer, the food processor, or consumer. All of the proteins that have been placed into foods through the tools of biotechnology are non-toxic, rapidly digestible, and do not have the characteristics of proteins known to cause allergies [5].

Positive health effects Of GM foods: Population increases, especially in developing countries, create the need for an ever-larger food supply. Many observers have suggested that biotechnology has the potential to increase world food output and reduce food insecurity by improving crop yields and reducing crop loss. As with any improvement in technology, farmers in developing countries must find the new advances profitable. Consumers in developing countries will benefit if biotech crops are less expensive or more nutritious than traditional crops.

To improve the Nutritional values: The human diet requires a certain number of vitamins and minerals to maintain a healthy balance for life. Not everyone eats a diet, through choice or necessity that is well-rounded in all these nutrients. The genetic modification process for food products can infuse these needed items into foods that may not normally contain them. By including these basic blocks of nutrition into more foods, fewer health issues due to malnutrition may arise over time [6]. Genetic engineering can now produce nutritionally enriched plants (e.g., "Golden Rice" has more Vitamin A due to incorporation of genes from a microbe and from daffodils), longer lasting plants, and plants with lower levels of naturally occurring toxicants. The goal of combining blueberries with tomatoes was to increase the amount of anthocyanin that people could receive in their diet. Anthocyanin is an antioxidant that may be able to fight cancer and provide other health benefits. The cost of this GMO food is often lower than natural blueberries or tomatoes, making it possible for most people to take advantage of the improve nutritional profile of the food during regular consumption [7].

Means of medication/pharmaceuticals: It is well known that medicines and vaccines often are costly enough to produce and sometimes require certain specific storage conditions. Continuous work along these specific line of action is on the way in view of developing certain edible vaccines in tomatoes and potatoes, probably will be rather easier to ship, store and administer compared to those pertaining to customary injectable vaccines [8].

The vaccines that we need to protect ourselves from dangerous diseases, along with certain medications that are useful for daily living, can be introduced into the very foods that we eat every day thanks to modern GMO practices. This would make it cheaper for people to have the medication access they need and could change how a visit to the doctor is handled in the future. You could get your flu shot while eating a peanut butter and jelly sandwich [9].

To reduce pesticide use: Pesticides are often sprayed on croplands to prevent certain pests from harming crops, which would reduce the potential harvest. Many pesticides are based on a chemical composition that can be harsh to the top soil. Many farms are forced to rotate their fields not because they are growing the same crops each year, but because the pesticides add salts to the soil that need to be removed over time [10].

To reduce herbicide use: Weeds are a major problem for croplands as well. A weed competes for the same resources that a food-producing crop requires to generate a harvest. The same issue which applies to pesticides applies to the application of herbicides. Spraying them too much, using traditional growing methods, can reduce soil nutrient levels over time. Genetic modifications which naturally prevent weeds from interfering can reduce the number

of chemicals introduced into the growing environment. In return, consistent yields can be created [10].

To reduce consumer costs: The average person in the United States will eat nearly 1 ton of corn over the course of a single year. That includes about 42 pounds of corn syrup each year. Genetic modifications to a core food product, such as corn, can reduce the cost of growing it. That reduces the cost of other food products that are made from the core food, which can save consumers money at the grocery store. Even if the savings were just $0.50 per pound, that would result in a total per-person savings of $750 per year [11].

Negative health effects of gm foods: The debates over GM foods focus mostly on uncertainties concerning the potential adverse effects of GM foods on human health and environmental safety. The anxiety among consumers can be attributed to four sources: the difficulty of the scientific community in explaining concisely to the lay public the biological techniques involved; concerns about the improper dissemination of GM foods; and the ethical principles inherent in traditional food processing; the misgivings with regards to the adequacy of evaluation of the GM foods [12]. Genetically Modified foods have a promising Human Health Hazards. In other ways GM organisms/foods have an effect on Environmental, Economy and Legal Issues which are also have indirect consequence on human health.

Human health hazards: Three major health risks potentially associated with GM foods are: toxicity, allergenicity and genetic hazards. These arise from three potential sources, the inserted gene and their expressed proteins per se, secondary or pleiotropic effects of the products of gene expression, and the possible disruption of natural genes in the manipulated organism [13].

Allergenicity: GM foods have the potential to cause allergic reactions in general; this risk is comparable to the risks associated with traditionally grown foods. However, the proteins produced by any newly introduced genes have the potential to cause an additional allergic response. To prevent such allergenicity, the transfer of genes from commonly allergenic foods is discouraged unless it can be proven that the protein produced by the introduced gene will not be allergenic. Also, tests are conducted to examine the heat and digestive stability of these proteins, and any similarity to known allergenic proteins. It is important to note that the traits that are introduced into a particular plant may be new to that plant but are often found naturally in other plants [10].

Increase antibiotic resistance: Development of resistance to antibiotics is a scourge well Known to medical science, and is traceable to the over-use of therapeutic antibiotics in medicine and agriculture. In the processes of genetic modification, antibiotics are also frequently employed, typically as selection markers, to distinguish success- fully transformed bacteria from those in which the transfecting genes did not take hold. Thus, the machinations to genetically modify an organism carries the risk of transferring the genes of antibiotics resistance into the benign bacteria comprising the microflora of human and animal gastrointestinal tracts, or, worse yet, to pathogenic bacteria harbored by the consumer of GM a food, because bacteria, good and bad, are quite capable of shuttling useful genes like those that protect them from nasty antibiotics around by horizontal transfer between species [14]. Having food products that can provide medication benefits to individuals may have many benefits. It may also have numerous unintended consequences. The amount of resistance that is currently being seen in bacterium populations to certain antibiotics is proof that nature knows how to adapt. Repetitive exposure to foods with medication qualities may not only reduce the effectiveness of that medication in each individual, but it may also speed up the resistance factor. Over time, that may cause problematic health consequences that may have no feasible fix [9].

Gene transfer: Another potential concern arising from GE foods is the transfer of genetic material from GE foods to the cells of the human body or the bacteria in the intestinal tract. DNA from ingested food is not completely degraded by digestion and small fragments of DNA from GM foods have been found in different parts of the gastrointestinal tract. This could result in horizontal gene transfer due to absorption of DNA fragments by gut microflora or somatic cells lining the intestinal cells. Dona and Arvanitoyannis have cited various studies that detected fragments of transgenic genes in the gastrointestinal tract, muscles, and white blood cells and milk of cows. Other scientists have shown limitations in the detection of GM DNA by currently available tests. Scientists have also postulated that uptake of GM DNA into the cells of the gastrointestinal tract will not have any biological consequences because this DNA will be degraded in the cells. However, it is not clear if people with gastrointestinal diseases will be able to fully degrade this GM DNA. A comprehensive scientific evaluation of this problem is a colossal task because only about 1% of the naturally existing bacteria can be cultured and thus analyzed [3].

Anti-nutrient effect: Anti-nutrients are substances that interfere with the utilization of nutrients. The insertion of a new gene may lead to an increase in the existing levels of anti-nutrients. For example, glyphosate resistant Roundup Ready soybean has been shown to increase anti-nutrients. In sheep and cattle, heat-stable anti-nutrients such as phytoestrogens, glucinins, and phytic acid have been found to cause infertility, allergic reactions, and decreased availability of phosphorus and zinc, respectively [15].

Environmental effects: Beyond the potential direct effects on human health, GM plants also have environmental effects on non-target organisms (organisms that are not pests), such as birds, insects, worms, bees, and fish. Other potential environmental risks are the persistence of the gene after the GMO has been harvested, and the potential for gene instability, biodiversity loss, or increased use of use of chemicals in agriculture. APHIS and the EPA do review any environmental impacts of GE crops prior to field testing and commercial release [10].

Economic effects: Although, Genetically Modified (GM) plants represent a potential benefit for environmentally friendly agriculture and human health, poor knowledge is available on the potential hazards posed by unintended modifications occurring during genetic manipulation. The major economic fears are the risk of patent enforcement which may oblige farmers to depend on giant engineering companies such as Monsanto for strains when their crops are cross pollinated. Consumer advocates are equally 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. It is hoped that in a humanitarian gesture, more companies and non-profits will follow the lead of the Rockefeller Foundation and offer their products at reduced costs to impoverished nations [1].

Legal issues: Genetically modified foods have been one of the most controversial topics that have made news in the last years. Many European environmental organizations, NGOs and public interest groups have been actively protesting against GM foods for months. Beside, recent controversial studies about the effects of genetically-modified food have brought the issue of genetic engineering to the forefront of the public consciousness [16,17].

Discussion

As [6,18], the genesis of DNA modification technology can be traced back to 1944, when scientists discovered that genetic material can be transferred between different species [12,19]. Also states, the double helix structure of DNA, and the "central dogma" DNA transcribed to messenger RNA, translated to protein was established. Developed DNA recombination technology, showing that genetically engineered DNA molecules can be transferred among different species. Undernourishment is very communal in third world countries where poor people trust in a single crop such as rice for the main staple of their diet. However, rice does not contain adequate amounts of all essential nutrients to avert malnutrition [20,21]. If rice could be genetically engineered to contain additional vitamins and minerals with an adequate nutraceutical (physiological and biochemical) significance, nutrient shortages could be relieved [6,22,23]. The nutritional content of the GMFs can be altered as well, and providing a denser nutritional profile than what previous generations were able to enjoy. This means people in the future could gain the same nutrition from lower levels of food consumption. The UN Food and Agricultural Organization notes that rice, genetically modified to produce high levels of Vitamin A, have helped to reduce global vitamin deficiencies [10,24,25]. This not only helps people get the nutrients they need, but also plays a significant role in fighting against malnutrition in third-world countries.

Through a process called "pharming," it is possible to produce certain proteins and vaccines, along with other pharmaceutical goods, thanks to the use of genetic modifications. The vaccines that we need to protect ourselves from dangerous diseases, along with certain medications that are useful for daily living, can be introduced into the very foods that we eat every day thanks to modern GMO practices [8,9,20]. This would make it cheaper for people to have the medication access they need and could change how a visit to the doctor is handled in the future.

Herbicides and pesticides create certain hazards on croplands that can eventually make the soil unusable. Farmers growing genetically modified foods do not need to use these products as often as farmers using traditional growing methods, allowing the soil to recover its nutrient base over time. Because of the genetic resistance being in the plant itself, the farmer still achieves a predictable yield at the same time [4, 10,26]. This means the amount of pesticide and herbicide chemicals used on the plants are reduced, so their exposures to dangerous pesticides are also reduced.

This improvement makes it possible to take excess food products from one community and deliver it to another that may be experiencing a food shortage. GMO foods give us the opportunity to limit food waste, especially in the developing world, so that hunger can be reduced and potentially eliminated [11,27,28]. Due to higher yield and lower costs, food prices would go down. As people in poorer countries spend over half of their income on food alone, this means automatic reduction of poverty.

Genetically Modified Foods may have numerous unintended consequences. The amount of resistance that is currently being seen in bacterium populations to certain antibiotics is proof that nature knows how to adapt [14,29]. Repetitive exposure to foods with medication qualities may not only reduce the effectiveness of that medication in each individual, but it may also speed up the resistance factor. Over time, that may cause problematic health consequences that may have no feasible fix [13]. This is may be due to the machinations to genetically modify an organism carries the risk of transferring the genes of antibiotics resistance into the benign bacteria comprising the microflora of human and animal gastrointestinal tracts, or to pathogenic bacteria harbored by the consumer of GM food.

Genetic migrations are known to occur within species. This happens with plants and animals. That's how we have numerous corn species, different grains, and other food products. What GMO foods do is combine unnatural combinations of DNA to create a new food product. Combining scorpion DNA into cabbage DNA is just one example of this process [3,18,24]. These combinations may create allergy triggers and unintended consequences, even if research shows certain combinations are not harmful to humans. According to [30], it is apparent that no standardized design to test the safety of GM foods yet exists. However, there is consensus that the safety assessment should be carried out on a case-by-case basis before a GM product is introduced to the market. Moreover, there is a need for standardization and harmonization of the design and analysis of animal feeding trials, as well as a particular need for appropriate statistical analysis of the data which is consistent with [31]. The current improvement of studies has produced a tendency to use more sensitive indicators, such as transcriptomics, proteomics, and metabolomics into the experimental risk assessment approach.

Bringing a GM food to market is a lengthy and costly process. 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, Patent enforcement may also be difficult, as the contention of the farmers that they involuntarily grew Monsanto-engineered strains [32,33]. One way to combat possible patent infringement is to introduce a "suicide gene" into GM plants. As [6] these plants would be viable for only one growing season and would produce sterile seeds that do not germinate. Farmers would need to buy a fresh supply of seeds each year. However, this would be financially disastrous for farmers.

As a reaction to the growing public concern on GM food and products, many governments across the world have taken different approaches to tackle this hot topic on GM foods. This has resulted in the creation of GMO regulations which are most often country or region specific [1]. The European parliament and council for example have set up regulations regarding GM foods to protect human

health and well-being of citizens, and European social and economic interests. As Strauss, D. M. 2006 the EU regulations segregates between GM food and feed, it further gives specific instructions on how GM products should be labelled in terms of the amount of modifications involved [34,35].

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. The latest development of biotechnology, particularly molecular biology, genetic engineering and transgenic technology has a very large number of potential applications in food production, including micro-organisms, plants and animals. GM foods have both positive and negative impacts. Genetically modified foods have numerous benefits like high return, cold, drought and salinity tolerance, insect resistance, herbicide and disease resistance, nutritional improvement, pharmaceutical and Phytoremediation functions. However GM foods have a lot of negative impacts on living beings. The drawbacks can be expressed as environmental hazards, health hazards, economic concerns as well as legal issues. The major health risks potentially associated with GM foods are toxicity, allergenicity and genetic hazards. These arise from potential sources, like inserted gene and their expressed protein sperse, secondary or pleiotropic effects of the products of gene expression, and the possible disruption of natural genes in the manipulated organism. Currently a biosafety regulatory regime has been developed in many countries to regulate the trans boundary movement of genetically modified organisms to avert their possible risks on biodiversity, human health and the environment in general.

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