Genetic Engineering and Biosafety in the use of Genetically Modified Foods

Ritu Mathur

Professor, Department of Food Science and Nutrition,
MDS University, Ajmer 305009, India

Abstract

According to the World Health Organisation, Genetically Modified Organisms (GMOs) can be defined as organisms (i.e. plants, animals and microorganisms) in which the genetic material (DNA) has been altered in a way that does not occur naturally by cross breeding, mating and/or natural recombination. In the present times the use of the term "genetic engineering" over "genetic modification" is more prevalent. This technology is also often referred to as "modern biotechnology" or "gene technology" or "recombinant DNA technology". Foods produced from or by using Genetically Modified organisms are referred to as GM foods. The first genetically modified plant was produced in 1983 using antibiotic resistant tobacco plant. Genetically modified microbial enzymes were the first application of GMOs in food production. Recombinant chymosin was approved for use in several countries. Tomatoes, potatoes, tobacco, canola, maize, cotton, soybeans and golden rice are some examples of Transgenic crops widely in use today. There has been a new GM food in 2015 i.e. genetically modified fish called Aqua Advantage and white button mushrooms in April 2016.The process of genetic engineering generally involves the addition of 1 or more genes to an organism's genome. The less commonly used techniques involves the use of some genes being removed or their expression is either increased or silenced. To cite some of the recent researches in the field of GMOs, Papaya has been genetically modified to resist the ring spot virus. The new leaf potato, a GM food has been made to provide in-plant protection from the yield robbing Colorado beetle. Zucchin has been modified to resist 3 viruses , GM pineapple, potato, corn and soya beans have also been developed. There is a scientific consensus that the foods derived from GM crops pose no greater risk to human health than conventional foods but that each GM food needs to be tested on a case to case basis before introduction. The legal and regulatory status of GM foods varies from country to country. In many countries they have been declared as GRAS-Generally Recognized as Safe. Testing on GMOs has been done using molecular techniques such as PCR and bioinformatics. Some disputes over the use of GM foods involve consumers, farmers, biotechnology companies, governmental regulators, NGOs, environmental and political activists and scientists. In conclusion it can be said that these modern engineered foods can go a long way in combatting malnutrition in a developing country like India. Scientists in this field need to carefullyassess their compliance to safety standards to ensure the good health and nutritional status of the citizens so as to enhance the best use of these Wonder Foods.

Introduction

Genetically modified foods or GM foods are also known as genetically engineered or bio engineered foods and these are foods produced from organisms that have had changes introduced into their DNA using the methods of genetic engineering. Genetic engineering techniques allow the introduction of new traits as well as greater control over traits than previous methods such as selective breeding and mutation breeding (GM Science Review Report 2013).

The 1st GM food that came into the market was FlavrSavr tomato with the delayed ripening gene (Clive 1996 and Weasel 2009). Most food modifications have primarily focused on each crop whichis in high demand by the farmers such as Soybean, Corn, Canola and cotton. GM crops have been engineered for resistance to pathogens and herbicides for better nutrient profiles, GM livestock have also been developed.

There is a scientific consensus that currently available food derived from GM crops poses no greater risk to human health than conventional food (Ronald 2011, Domingo, 2011, Nicolia et al, 2013, SFA 2016), but that each GM food needs to be tested on a case to case basis before introduction. (WHO

2016, Alexander 2003, British Medical Association, 2016). The legal and regulatory status of GM foods varies by country with some nations banning or restricting them and others permitting them with widely differing degrees of regulation.

In the US the Food & Drug Administration favours the use of the term "Genetic Engineering" over "Genetic Modification" as the more precise term. (USDA 2013).

History of GM Foods:

The process of selective breeding in which organisms with desired traits / genes are used to breed the next generation and organisms lacking the trait are not bred is a precursor to the modern concept of genetic modification. With the discovery of DNA in the early 1900s and various advancements in the genetic techniques through the 1970s it became possible to directly alter the DNA and genes within food (Jackson, 1972). The first genetically modified plant was produced in 1983 using an antibiotic resistant tobacco plant. Genetically modified microbial enzymes were the first application of genetically modified organisms in food production. Cheese was made using the enzyme complex Rennet which was extracted from the cow's stomach lining. Scientists modified bacteria to produce chymosin which was also able to clot milk resulting in cheese curds,

The first genetically modified food approved for release was the FlavrSavrtomato in 1994 which was engineered to have a longer shelf life by inserting an antisense gene that delayed ripening. Then followed GM crops like potato, Bt. maize, Bt cotton, glyphosphate tolerant soybeans and golden rice in the year 2000 (James 2011).

Steps to Genetically Modify a Seed

Steps 1: Finding a new trait

To produce a GMO it is important to identify the new trait desirable for the plant to have and also to discover which other organisms already have this desirable trait. This involves luck and careful searchingforeg. glyphosphate tolerant plant was developed using the gene from a bacteria, similarly fatty acid composition of several flowers and fungi were studied and finally fatty acid producing enzymes were found in primrose flower and a mould called neurospora. Concocting a transgenicsoybean seed also involved testing the plant themselves to find the most worthy subjects.

Steps 2 : Grabbing Genes

Engineers invented a special chipping device that shaves off just a tiny piece of the seed and grinds it into a powder that can be analysed with genome mapping technology, the viable remainder of the seed is preserved for planting and cultivation.

Step 3: Trait Insertion

This is generally done using the "gene guns" that literally shoot pieces of DNA. A 22-calibre charge fire a metal particle coated with DNA into plant tissues. Another technique can use a bug to invade into plant DNA and tricking it to produce sugars and amino acids that feed the bacteria.

Step4: The growth chamber gauntlet

Growth chamber, green houses and laboratories are home to countless, thousands of seedlings being tested for drought tolerance, salt tolerance, pest and disease resistance and more.

Step 5: Planting

The planter sows seeds at variable speeds of spacing providing a well-roundedpicture of how plants grow in certain conditions.

Step 6: The genes express themselves

It is important to prevent weeds from stealing their nutrients& keep pests from harming the crops before harvest

The health benefits and concerns of some GM foods

1)   Genetically modified Tomatoes

Tomatoes were one of the first genetically modified vegetables available to the masses.To evaluate the goodness of tomatoes scientists come up with the idea of genetically modified tomatoes in 1994 known as FlavrSavr. These were transgenic tomatoes made by deactivating a particular gene in them.

Process – before the birth of the ripe tomato the vegetable was harvested while it was still raw and then ripened artificially during the transit or in storage. This was done to ensure that the end consumers received ripe tomatoes in premiere condition without softening.

When the FlavrSavr tomato was brought into the market, it was a tomato that was made by a process called the antisense approach. Because of a deactivated gene the tomato plant was no longer able to produce an enzyme known as polygalacturonase which was responsible for fruit softening. The tomatoes could now be left to ripen in the vine and still have a longer shelf life.

Advantages of GM Tomatoes

- Can tolerate lengthier transport time
- Could gain all the nutritional qualities of ripening
- Could be harvested simultaneously

- Longer shelf life

Concerns about GM Tomatoes
- Threat of the plant gaining undersirable properties
- Change in the microbial quality of the soil due to the modified crop grown
- If the food product was made antibiotic resistant it could have the same effect on humans when consumed, leading to failure of antibiotic based treatment.
- Probable biological disaster if some undesirable traits were transferred to animals & humans after eating the altered tomato (http// www.gm. org/gm.foods/genetically modified building.better.tomatoes)

**2)	Genetically Modified / Transgenic Rice – Golden Rice**
There are 124 million children in the world who are sufferersof Vitamin A deficiency.Vitamin A is required by all individuals and its deficiencycausesnight blindness. Rice is used as a staple food in almost every country. Rice provides as much as 80% or more of the daily caloric intake of 3 billion people which is half of the world's population. This golden rice could save a million kids a year. Prof. IngoPotrykus& Peter Beyer produced genetically engineered rice by introducing 3 genes associated with the biosynthesis of carotenoid. The transgenic rice was rich in provitamin A. Grains of transgenic rice are yellow in colour due to provitamin A, the rice is commonly known as "Golden Rice".

**3)	Genetically Modified Potatoes**
Another future GM potato is the protein packed potato developed in India. Researchers in India have created a potato with 35 to 60% more protein. This potato uses the gene from amaranth seed. This potato would be beneficial to human health in developed and developing countries and help fight malnutrition in India especially in children.

Advantages of GM Potatoes
- Decrease in cost of production, less money spent on pesticides & insecticides
- Better for the environment, less chemicals used to resist pests
- Less pesticides better for farmers health
- High in nutrients, the protein packed potato
- Reduces soil erosion
- Better quality potatoes

Disadvantages of GM Potatoes

- Can cause antibiotic resistance
- Cause health problems for animals eating the product
- Some GM foods may contain allergens and toxins
- Gene transfer may occur between organisms

**4)	Genetically modified Soybeans**
The Roundup Ready Soybean also known as Soybean GTS 40-3-2 is a transgenic soybean that has been immunized to the Roundup herbicide.Since the soybean's natural trypsin inhibitors provide protection against peststhe only major problems in soy farming was weeds thus making 40-3-2 revolutionary. A plasmid was transferred to the soybean cells through the cauliflower mosaic virus and was soon developed to provide immunity to glyphosphate containing herbicides and after this process was perfected the RoundupReady.
Soybean was ready which first hit the US market in 1996. Mausanto developed a soybean expressing Gy1Ac proteins from Bacillus thuringiensis and the glyphosphate resistance gene Transgenicsoybean oil has also been developed with increased oxidative stability

Genetically Modified Corn Bt Corn
Genetically modified corn is engineered to produce a soil bacterium called bacillusthuringensis or Bt which is an effective insecticide. Bt corn reduces pesticide usage. Bt corn is created by inserting a gene into the DNA of the plant that casus the corn to produce a protein called Bt delta endotoxin, the protein islethal to certain crop destroying larvae. When insects ingest the endotoxin, it breaks down the wall of the gut, leaking the bacteria throughout the insect's body& causing death by septicemia. The US Food & Drug Administration & the Environmental Protection Agency have determined that BtCorn is safe for human consumption. The major advantage of Bt corn is that it reduces the need to use broad spectrum insecticides. Most pesticides that are sprayed onto the crops kill all insects including harmless and beneficial ones. In contrast, Bt is specific to a few insects that are susceptible to the toxin and only kills insects that have ingestedBt corn. Because there is less usage of chemical pesticides with Bt corn, cost of production is lower and exposure to hazardous chemicals by the farmers isreduced

Health and safety concerns of BT Corn
- Reduces pesticide use
- May trigger an allergic response
- Safe for human consumption.

Advantages and Disadvantages of Genetically Modified Foods

Advantages of Genetically Modified Foods

1. Insect Resistance
Some GMO foods have been modified to make them more resistant to insects and other pests. A report from the University of California states that toxic bacteria (yet safe for human use) can be added to crops to make them repel insects. This means the amount of pesticide chemicals used on the plants are reduced, so their exposure to dangerous pesticides are also reduced.

2. Stronger Crops
Another benefit that GM technology is believed to bring about is that crops can be engineered to withstand weather extremes and fluctuations, which means that there will be good quality and sufficient yields even under a poor or severe weather condition. As populations across the world grow and more lands are being utilized for housing instead of food production, farmers are prompted to grow crops in locations that are originally not suitable for plant cultivation, and culturing plants that can withstand high salt content in soil and groundwater, not to mention long periods of drought, will help them grow healthy crops. Also, animals and plants that have been genetically modified can become more resistant to unexpected disease problems. We can just think of the technology as a vaccine for the species, except that it is encoded into their genes, rather than being shot into their immune system.

3. Larger Production
It has been easier to raise crops that are classified as genetically modified because all of their examples have the stronger ability to resist pests. This attribute helps farmers with producing greater amounts of crops or foods.

4. Environmental Protection
According to an Oklahoma State University report, the increase of GM animals and crops often requires less time, tools and chemicals, and may help with reducing greenhouse gas emissions, soil erosion and environmental pollution. This means the general health and beauty of the environment that surrounds farms will be improved, contributing to the preservation of better water and air quality, which can also indirectly benefit every person's well-being.

5. Extensive Protection for Crops

GM foods were created with the use of genetic engineering—a technology that was designed to make sure crops will never be damaged in a fast rate. The method also allows farmers and merchants to preserve the good quality of foods more efficiently by using special substances.

6. More Nutritious Foods
According to the Food and Agricultural Organization of the United Nations, some GM foods have been engineered to become more nutritious in terms of vitamin or mineral content. This not only helps people get the nutrients they need, but also plays a significant role in fighting against malnutrition in third-world countries. In fact, the United Nations recommends that rice that is enhanced with vitamin A can help with reducing deficiencies of such nutrient around the world.

7. Decreased Use of Pesticides
It has been proven that genetically modified crops do not need pesticides to become stronger against various types of insects or pests that may destroy them.

8. More Income
With genetic engineering, farmers will have more income, which they could spend on important things, such as the education of their children for example.

9. Less Deforestation
To sufficiently feed the growing population of the world, deforestation is needed. But with genetically modified animals and crops, the use of this method will be minimized. This would decrease carbon dioxide in the atmosphere, which would, in turn, slow global warming.

10. Decrease in Global Warming
As more plants and crops can be grown and at more areas, including those that were previously unsuitable for farming, oxygen in the environment is increased, decreasing the proportion of carbon dioxide and, in turn, reducing global warming. In fact, British economists noted in a study that genetically modified crops have made significant contribution to reducing greenhouse gas emissions by over 10 million tons, which is equivalent to removing 5 million cars from the road each year. This means that people would not have to give up their vehicles.

11. Decrease in Food Prices
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.

12. New Products

New kinds of crops are being developed to be grown at extreme climates, such as those present in dry or freezing environments. As an example, scientists have developed a new type of tomato that grows in salty soil. Another good discovery in genetic engineering of plants is the exclusion of the gene responsible for caffeine in coffee beans, creating decaffeinated coffee beans, which can then be grown naturally.

Disadvantages of Genetically Modified Foods
1. Allergic Reactions

According to a research study genetically modified foods can pose significant allergy risks to people. It states that genetic modification often adds or mixes proteins that were not indigenous to the original animal or plant, which might cause new allergic reactions in our body. In some cases, proteins from organisms that you are allergic to might be added to organisms that you were not originally allergic to. This means your range of food choices will be lessened.

2. Not 100% Environmentally Friendly

Though it is claimed by many experts that genetically modified foods are safe for the environment, they actually still contain several kinds of substances that are not yet proven to be such.

3. Lower Level of Biodiversity

One big potential drawback of this technology is that some organisms in the ecosystem could be harmed, which in turn could lead to a lower level of biodiversity. When we remove a certain pest that is harmful to crops, we could also be removing a food source for a certain species. In addition, genetically modified crops could prove toxic to some organisms, which can lead to their reduced numbers or even extinction.

4. Decreased Antibiotic Efficacy

According to the Iowa State University, some genetically modified foods have antibiotic features that are built into them, making them resistant or immune to viruses or diseases or viruses. And when we eat them, these antibiotic markers will persist in our body and will render actual antibiotic medications less effective. The University also warns that ingestion of these foods and regular exposure to antibiotics may contribute to the reduced effectiveness of antibiotic drugs, as noticed in hospitals across the planet.

5. Unusual Taste

Genetically modified foods are observed to have unnatural tastes compared with the ordinary foods that are sold on the market. This could be the result of the substances that were added to their composition.

6. Not Totally Safe to Eat

It is proven by scientific studies that GMO foods contain substances that may cause diseases and even death to several kinds of species in this world, including us humans. For instance, mice and butterflies cannot survive with these foods.

7. Cross-Pollination

Cross-pollination can cover quite large distances, where new genes can be included in the offspring of organic, traditional plants or crops that are miles away. This can result in difficulty in distinguishing which crop fields are organic and which are not, posing a problem to the task of properly labeling non-GMO food products.

8. Gene Spilling

It is unclear what effects, if there are any, the genetic pollution resulting from inadequate sequestering of genetically modified crop populations would have on the wild varieties surrounding them. However, it is stressed that releasing pollen from genetically altered plants into the wild through the insects and the wind could have dramatic effects on the ecosystem, though there is yet long-term research to be done to gauge such impact.

9. Gene Transfer

Relevant to the previous disadvantage, a constant risk of genetically modified foods is that an organism's modified genes may escape into the wild. Experts warn that genes from commercial crops that are resistant to herbicides may cross into the wild weed population, thus creating super-weeds that have become impossible to kill. For genetically enhanced vegetation and animals, they may become super-organisms that can out-compete natural plants and animals, driving them into extinction.

10. Conflicts

GMO foods can cause a lot of issues in the merchants' daily life. How? These products might encourage authorities to implement higher tariffs to merchants, who would be selling them.

11. Exploitations

Some countries may use genetic engineering of foods as a very powerful weapon against their enemies. It is important to note that some scientists have discovered that these products can kill a lot of individuals in the world by using harmful diseases.

12. Widening Gap of Corporate Sizes

This disadvantage can possibly happen between food-producing giants and their smaller counterparts, causing a consolidation in the market. There would be fewer competitors, which could increase the risk of oligopolies and food price increases. Moreover, larger companies might have more political power and might be able to influence safety and health standards.

13. New Diseases

As previously mentioned, genetically modified foods can create new diseases. Considering that they are modified using viruses and bacteria, there is a fear that this will certainly happen. This threat to human health is a worrisome aspect that has received a great deal of debate.

14. Food Supply at Risk

GMO seeds are patented products and, in order to purchase them, customers have to sign certain agreements for use with the supplier or creator. As the reliance on these seeds expands around the world, concerns about food supply and safety also continue to arise. Furthermore, these seeds structurally identical, and if a problem affects one of them, a major crop failure can occur.

15. Economic Concerns

Bringing a genetically modified food to market can be a costly and lengthy process, and of course, agricultural bio-technology companies want to ensure a profitable ROI. So, many new plant genetic engineering technologies and products have been patented, and patent infringement is a big concern within the agribusiness. Also, consumer advocates are worried that this will raise seed prices to very high levels that third-world countries and small farmers cannot afford them, thus widening the gap between the rich and the poor.

One way fight against possible patent infringement is introducing a "suicide gene" into GM animals and plants, which would be viable for only a single growing season and would produce sterile seeds that do not germinate, prompting farmers to buy a fresh supply of seeds every year. However, this would be financially disastrous for them, especially those in developing countries, who cannot afford to do this and traditionally set aside a portion of their harvest to plant in the next growing season. (http://connectusfund.org)

Conclusion

Genetically modified foods can potentially solve many hunger and malnutrition problems in the world, as well as help protect and preserve the environment by increasing yields and reducing reliance upon chemical pesticides and herbicides. However, it is important to proceed with caution to avoid unfavorable consequences for the surroundings and our health, considering that genetic engineering technology is very powerful.

Remember that there are really potential benefits and risks to these products, which you will learn further as you dig deeper into this subject. You can also read a brief fact sheet to familiarize yourself more with their purported benefits and problems. By doing so, you will be well-informed about these foods and the way they can affect your life.

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