

Analysis

Insight into the Genetically Modified Foods: Concerns of Safety to Food Development (Part II)

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SUMMARY

There are a lot of non-food uses of GM plants like timber, use to manufacture paper, in the chemical industry and as biofuels. Pharmaceuticals made from proteins can be made from GM plants. Plant tissues in the processed shape can be used potentially as edible vaccines. According to an estimate, 250 acres of greenhouse space can be enough to let the GM potatoes grow and meet the annual demand of hepatitis B vaccine in the whole South East Asia. Any harmful effect on the environment through large-scale growth of GM plants can indirectly show impacts upon human health. GM plants are also evaluated on the basis of how they might have a constructive role to perform in the environment by partial removal of contaminants – a practice often termed as phytoremediation. A lot of NGOs and media organizations are ruthlessly opposed to production of GM plants. Scientists need to engage the common man to ensure that the issue demands more rational approach of thinking. The opposition is making serious impacts as many underdeveloped countries that can get a lot of advantage from this technology. ■

KEYWORDS Genetic engineering; Foods; Population health; Toxicity; Genetic pollution

Sci Insiqt. 2016; 2016:e00270. doi:10.15354/si.16.vi011

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NON-FOOD USE OF GM PLANTS

A lot of uses of plants exist outside the food industry, like timber, use to manufacture paper, in the chemical industry and as biofuels. Both GM and non-GM styles are adopted. GM plants have a significant use in the production of recombinant pharmaceuticals. Molecular farming is in study under academicians and industrialists for production of GM plant-derived pharmaceutical proteins termed as PDPs. The first full sized native human recombinant plant-derived pharmaceutical protein, human serum albumin was expressed in 1990 (1) and since that time, antibodies: blood products: hormones and vaccines have been expressed in plants (2).

Pharmaceuticals made from proteins can be made from GM plants. Plant tissues in the processed shape can be used potentially as edible vaccines. Since the molecular farming industry is newborn, only a single product is approved to be used; recombinant human intrinsic factor to be used in B12 deficiency. However, many are in the trial process including hepatitis B vaccine that is produced in potatoes and lettuce (3), heat labile toxin vaccines produced by *E. Coli* and Norwalk virus, human pro-insulin (4) and some monoclonal antibodies (5).

Using GM plants to produce pharmaceuticals as advantageous over traditional methods. For example; they can help in production of complex multimeric proteins like antibodies, which cannot be expressed by microbial systems. Moreover, pharmaceutical production can be on a large scale. Hence it is, in particular, important as it opens doors for new applications needing to administrate proteins in large amounts. They include the use of antibodies and microbicides on the mucosal surface to prevent it from being infected. All the applications are, however, not on a larger scale. For example; hepatitis B vaccine is produced in GM yeast, but it cannot be produced at a large scale to meet the increasing demand in developing countries (6).

According to an estimate, 250 acres of greenhouse space can be enough to let the GM potatoes grow and meet the annual demand of hepatitis B vaccine in the whole South East Asia.

In the present times, more than three million people are dying every year from diseases that can be prevented through vaccines. Most of the victims belong to developing countries. Present model of profit based pharmaceutical companies cannot produce fruitful results in getting rid of diseases in the developing world. GM plant technology can be a very sound alternative since it can be applied locally by scientists in under-developed regions who work in collaboration with governments or with non-profit research funding agencies.

Some objections have been raised to the use of plants for manufacturing of recombinant pharmaceuticals. The biggest one is this that the pharmaceutical may enter the food chain of humans. Theoretically, it may happen as a

result of uncontrolled dispersal of GM seed or due to hybridization with a sexually compatible food crop that follows the escape of GM pollen. In 2002, Prodigene company was fined and censured for violating the safety regulations as GM maize expressed a PDP and was found to be growing in the crop of soybean destined for food consumption in the next growing cycle (7).

Although not too often, but incidents like this show a risk of technology when not handled with great care. One of the proposals is to limit the molecular farming to non-food crops such as tobacco.

There are advantages of using food crops for recombinant pharmaceutical production like attaining GRAS (Generally recognized as safe) status and using right agricultural techniques for production.

Environment and GM plants

Effects on environment affect the human health. Any harmful effect on the environment through large-scale growth of GM plants can indirectly show impacts upon human health. Some of the concerns expressed in relation to GM plants and the environment are:

- GM plants would sexually hybridize with the non-GM plants by transferring pollen
- GM plants themselves can spread quickly and undesirably
- Conditions required to produce GM plants affects the local wildlife populations

In 2001, a highly publicized study showed that GM genes from genetically engineered maize had contaminated the wild maize in Mexico – the global center for biodiversity of the specie, by cross-pollination (8). The authenticity of this study was, however, conflicted at the publication time (9), and then further studies have also been failed to note any example of transgene spread in Mexican maize, growing in the world (10).

Recently, it was reported that some creeping GM herbicide-resisting bentgrass (*Agrostis stolonifera* L) that was planted in Oregon, USA went 3.8 km outside the area that was designated for its cultivation (11).

The researchers of this study proposed that the widening of plant was a consequence of both pollen-mediated sexual crossings with wild plants and dispersal of GM crop seeds. In 1999, a paper was published positing that the maize genetically engineered to express insecticidal Bt toxin was devastating for larvae of Monarch butterfly – iconic specie in the American culture (12). The larvae grown on food of milkweed that is dusted with pollen from the Bt maize, consumes less and grow slowly while suffering high mortality rates. Long term studies hypothesized the chance of Monarch butterfly larvae to be exposed to Bt maize pollen naturally illegitimate a toxic response. And this was found to be insignificant (13).

Evaluating the effects of GM crops on surrounding wildlife is not easy when considering long lasting impacts.

In particular, it is difficult to find the required regime for their growth. UK based farm scale evaluations were the largest study of environmental effects of GM crops comparing to any other study in the world. During the four-year program, the effects of management practices that are linked with the “genetically modified herbicide tolerance” on farm wildlife as compare to conventional weed control. Research stated that among three of the tested four crops, wildlife was actually reduced in the GM fields, compared to non-GM. But in final crop (maize) it went oppositely.

According to researchers, the difference was not due to crops being genetically modified but due to farmer’s use of different herbicide regime as compared to conventional crops. Study provided a platform to government for evaluation of impacts of crops. Although the results derived were faced by critics of technology as an evidence of environmental hazards of GM, government approval was obtained for commercializing herbicide-resistant GM maize in UK.

GM plants are also evaluated on the basis of how they might have a constructive role to perform in the environment by partial removal of contaminants – a practice often termed as phytoremediation. For instance, plants already are being genetically modified to amass heavy metal soil pollutants like mercury and selenium up to an even higher level than the one possible for non-engineered plants (14). So they may not only breed on polluted locations but can also repair contaminations. We can harvest and destroy such plants, heavy metals can be disposed of and recycled and the decontaminated field may be reused.

GENE TRANSFER IN THE ENVIRONMENT

Different approaches are suggested to stop the flow of gene from GM plants to broader environment. Transferring the gene to a wild or non-GM crop is a special concern when it expresses a protein that is designed for industrial or pharmaceutical use. It is a matter of large agreement that foods should be free of products that are specifically manufactured for such applications. Two important techniques of preventing it from occurring are:

- Physical isolation and
- Genetic containment

Physical isolation is tough and expensive and needs to be carried out frequently (at each stage of production). The crop needs to be bred in isolation and both the small and large-scale field trials ought to be carried out in isolated areas.

The seed and commercial crops can be grown in contained greenhouse conditions or in places free of weed or food crop relatives. Moreover, the earth growing GM crops and the surrounding fields ought to be left to ‘lie fallow’ for some time ensuring no seeds to remain and grow in the upcoming crop cycle. Most favorable approach is to have a number of specified farms where proper planting is done

and equipment to harvest, transport, grain-handling, drying and storage systems is available (15).

We can achieve genetic containment at different levels through technological means. Existing infertility and incompatibility systems limiting the transfer of pollens may be used as well as Genetic Use Restriction Technologies (GURTS) that hinder with fertility or seed formation. Transferring foreign genes into chloroplast genome is also a technique, as in various plant species; chloroplasts are inherited maternally and not confined in pollen.

It is neither a new phenomenon nor confined to GM plants that crops for human consumption co-exist along with the related varieties that are grown for industrial products and harmful for human consumption. For instance, Canadian farmers grow two varieties of non-GM rapeseed that are high and low producers of erucic acid. Erucic acid being extracted from high producing variety has a use as an industrial lubricant and harmful for humans if consumed. ON the other hand, the low producing rapeseed variety (canola) is consumed in homes as cooking oil. Local famers take care in keeping the two away during growth and processing.

GM PLANTS AND PUBLIC OPINION

A lot of NGOs and media organizations are ruthlessly opposed to production of GM plants. Crops such as Golden Rice, designed to help alleviate malnutrition in the under-developed countries, are criticized on the basis that it ‘tastes terrible’ and ‘to be of any good if a child eats around 7 kg of cooked Golden Rice; an over-estimation by greater than fifteen times as per the product’s founder. Genetically modified insect-resistant cotton to produce Bt toxin demands lesser application of pesticide and produces greater crop yield than that of non-GM equivalent, producing a revenue of up to \$500 per hectare for the farmer (16).

Apart from this, the crop has been criticized on the unproven basis that it slays the natural parasitic enemies of cotton bollworm and increases a lot of other pests. Moreover, its success is claimed to be short-lived, as the bollworm would become resistant to insecticides. Such allegations have been made despite the fact that Bt bacteria has widely been used in the form of a spray on organic crops by farmers for decades and no resistance developed in insects as well as no emergence of resistance after eight years of growing GM crop.

In some places, GM foods are termed as unnatural although this allegation implies to all of our foods that have been in production over millennia via artificial breeding. There is a slight probability of commercialized crops to survive without any such measure. While considering the natural production of food, technology must be acknowledged of playing a very vital role in the food industry helping the human kind. For example, the use of antibiotics is very wide in the feed in poultry industry. Modern varieties of wheat are produced by the help of radiation-induced mutation (17).

It's insane that the scientists who genetically engineered the frost-resistant plants by the help of gene from cold-water fish were met with disgrace and atrocity. Yet both the fish and plant share a huge portion of genes in common; as all the living creatures do. (18)

The disagreement to the GM crops is supposed to be more in EU as compared to rest of the world. Like in USA, food from genetically modified crops has become a routine diet. However, the situation is a bit complex and public opinion in EU is perhaps less against the GM crops as it is believed to be. A survey acknowledged that only 13% of the consumers actually avoid GM foods while a large proportion (74%) had no particular concern to avoid it. It is surprising to have considerable anti-GM media coverage. Watching television and going through print media shows that the public is stubbornly against GM foods; but the survey tells a complete different story (19).

Nonetheless, GM crops do face lots of critic. Scientists need to engage the common man to ensure that the issue demands more rational approach of thinking. The opposition is making serious impacts as many underdeveloped countries that can get a lot of advantage from this technology. Such countries would certainly not accept the advancement as long as there remains any serious concern. Improving and implementing GM crops will. Thus, it shall be proving very helpful to alleviate the present and future challenges for supply of food and medicine.

We know that food security is a problem when all people have a significant physical and economic access towards adequate, safe and nutritive food. But the food security does not exist for a big proportion of the world. About 795 million people face undernourishment in the whole world suffering undersupply with calories (20).

A lot more suffer from shortage of nutrition, more often linked with inadequate micronutrients. United Nation's most important goal is to alleviate hunger. But achieving this goal is still controversial. Genetically Modified crops are highlighted in this regard. They can prove very helpful becoming a bridge between need and demand of food considering that population is growing (21) while agricultural land is shortening while in view of other people, this technology can be a bigger risk to food security.

There are three possible ways by which GM crops can effect on food security.

- Genetically Modified crops can help food production increase and thus improve the access of food at global as well as local level.
- They affect the food security as well as food quality.
- GM crops can influence economic and social condition of farmers and may improve (or sometimes worsen) their economic access to food.

The last aspect is of considerable importance, as we know that about half of world's undernourished people are the small-scale farmers in the underdeveloped countries. In respect to the first attribute, GM technology can produce high yielding food crops and stout to the biotic as well as

abiotic stresses (22). This may stable and increase the food supply as the climate is changing, land and water are shortening and the demand of ample food is increasing. In 2012, around 170 million hectares (12% of the arable land globally) were planted with the GM crops like soybean, cotton, canola, corn, etc. (23).

But most of them were not grown in order to consume them directly as food but for industrial use. Agricultural commodities cost greater without productivity gains from the GM technology (24).

The effects on food availability can be greater if GM food crops are commercialized. One of the reasons of not a wide application is the lack of public acceptance towards it. Let's talk about the second pathway. Crops with new characteristics are associated with risk in food safety that needs to be evaluated and managed as per the case. However, such risks are not only limited to GM crops. Long-term research shows that GM tech is not as such riskier that the conventional breeding techniques. Conversely, Genetic Engineering may help to breed food crops with greater contents of micronutrients; as the Golden Rice with vitamin A in the grain (25).

Such GM crops haven't been commercialized yet. It is forecasted that GM technology will reduce the nutritional deficiency among the poor people and the outcome shall be in the form of positive health effects (26).

The third pathway belongs to the use of GM crops by small-scale farmers in the underdeveloped world. Half of the GM crop area worldwide is present in the developing countries. However, most of it is part of large farms in South America. A notable one is "Bacillus thuringiensis" cotton that is grown by 15 million small-scale farmers in India, Pakistan, China and few other countries. It resists many pests; especially cotton bollworms. Studies have shown that Bt cotton significantly reduces the use of chemical pesticides and hence, helps the farmer increase the production to an effective level (27).

Some other researchers have shown that the benefits are linked with the increase in farm household earning and better living standards. Crops like cotton are non-food cash crops, so the nutrition is, however, uncertain. Higher income means an increase in the food consumption in poor homes.

Calories consumed in rural India come from the cereals like wheat, millet, rice and sorghum that have a lot of carbohydrates but not nutritious in terms of proteins and micronutrient content. Thus, apart from total consumed calories, we need to calculate the number of calories from greater number of nutritious foods in order to manipulate the quality of diet. By "more nutritious foods", we mean pulses, fruits, vegetables and dairy products like milk, butter, meat, fish, eggs, etc. A recent study showed that the calories consumed from higher value, non-staple foods can contribute to nutritional sufficiency (28).

Most of the poor and undernourished people try to choose the food that is the cheapest source of calories; cere-

als in India for example. They only think of other sources that are expensive when they have sufficient money or when cereals cannot meet the need of nutrition required by the body.

It is to be noted that the data of food consumption from home surveys does not always provide the accurate data to analyze the nutritional status by one reason or the other (29). Also, the consumption data overestimates the calorie consumption since no estimate can accurately take into account the food losses, wastes and other uses within the home. However, both the adopters and non-adopters of Bt face this limitation. Thus, to compare Bt and non-Bt, relevant to impact assessment, remains unaffected.

ADVANTAGES AND DISADVANTAGES

Now, at the end, we shall discuss some advantages and disadvantages of genetically modified crops (30).

- They are better for the environment as they require less chemicals. The pesticides used on non-GM crops emit harmful greenhouse gases and pollute the soil as well as the air.
- In GM crops, capability of resistance to diseases is greater. This actually means higher yield and low price for consumer.
- They can meet the ever-growing needs of food for the whole population of world.

- GM foods also have a longer shelf life. Hence they remain fresh for longer period during transportation and storage.
- The biggest perk of GM crops on our lives is the affordable rate at which they can be produced and commercialized.

Major disadvantages of GM crops are:

- Pollen from GM plants is pollinated. When it is round other plants, things like grass and weed cross-pollinate due to which superweeds are developed that have significant resistive properties equivalent to that of crops.
- Childhood food allergies have been increased since GM foods started. Although no link is found between both but many believe this since the area is lacking research.
- The crops have antibiotic properties induced into them. Thus when we consume them, some effects are left into our bodies making antibiotics less effective.
- Long term effects have not yet been discovered and hence people cannot go easy with high use of such foods.

On a lighter note, advantages of GM foods are more powerful. We need to understand and accept the need of technology. ■

ARTICLE INFORMATION

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Author Contributions: All authors have full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: All authors.

Acquisition, analysis, or interpretation of data: All authors.

Drafting of the manuscript: Chow and Norris.

Critical revision of the manuscript for important intellectual content: All authors.

Statistical analysis: N/A.

Obtained funding: N/A.

Administrative, technical, or material support: Bilder.

Study supervision: Bilder.

Conflict of Interest Disclosures: All authors declared no competing interests of this manuscript submitted for publication.

Funding/Support: N/A.

Role of the Funder/Sponsor: The funding supporters had no role in submitting and publishing the work.

How to Cite This Paper: Chow S, Norris J, Bilder BG. Insight into the genetically modified foods: From the concerns of safety to food development (part II) 2016; 2016:e00270.

Digital Object Identifier (DOI):

<http://dx.doi.org/10.15354/si.16.vi011>.

Article Submission Information: Received, August 28, 2016; Revised: September 26, 2016; Accepted: October 04, 2016.

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