Genetically Modified Food: How Safe are They?

Dr Niranjan Rajapakse

What are Genetically Modified Foods?

An entire set of DNA molecules in the nucleus of eukaryotic organisms is called the genome. Genes are fragments of DNA that transfer inherent characteristics of organisms from one generation to the other. Sexual reproduction facilitates mixing of these genes and natural alterations to the genetic materials, leading to changes in phenotypic characters of organisms over time. The genomes of plants and animals were subjected to alterations through selection, seeking better phenotypic characters for many years using traditional breeding techniques. Artificial selection of organisms for specific, desired traits has resulted in a variety of different organisms, but this artificial selection, in which organisms that exhibit specific traits are chosen to breed subsequent generations, has been limited to naturally occurring variations.This natural transfer of genes is possible among organisms only when they are with close genetic distance.

With the discovery of the structure of DNA in 1953, and particularly since the development of tools and methods to manipulate DNA in the 1970s, it was discovered that DNA can be transferred between genetically distant organisms using artificial methods. In this method a specifically cut out gene from one organism is paste into a genome of another. As a result, a new scientific technology was evolved enabling specific modifications to the genetic material targeting introduction of new characteristics to the living organisms. Genetic engineering, also called genetic modification or genetic manipulation, is the direct manipulation of an organism's genes using biotechnology. Combining together of genes from two different species is known as recombinant DNA technology, which comes under the broad term biotechnology and the resulting organism is identified to be genetically modified (GM), genetically engineered (GE), live modified or transgenic. In brief, genetic modification or genetic engineering techniques enable scientists to find individual genes that control particular characteristics, separate them from the original source, and transfer them directly into the cells of an animal, plant, bacterium, or virus.These new genetic combinations paved the path to introduce new characteristics to the crop plants such as resistance to drought, soil salinity, pest and diseases, herbicides and elevated levels of nutrients and phytochemicals created a revolutionary change in crop improvement. A large number of genetically modified (GM) crops, including both food and non-food crops carrying novel traits have been developed over the years.

Table 01: Some of the genetically modified crops approved for human consumption

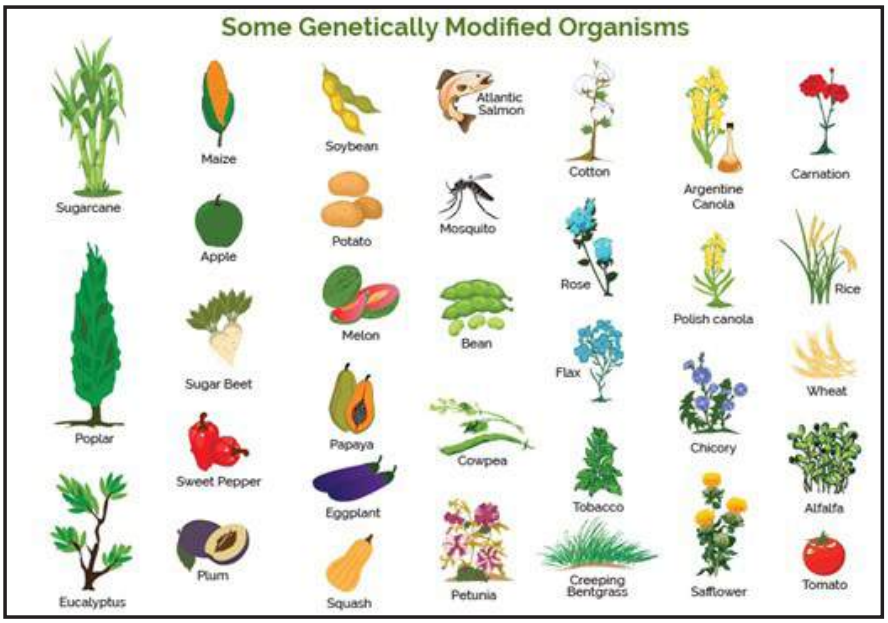
Crop	Scientific Name	Crop	Scientific Name
Apple	*Malus domestica*	Potato	*Solanum tuberosum*
Canola	*Brassica napus*	Rice	*Oryza sativa*
Bean	*Phaseolus vulgaris*	Soybean	*Glycine max*
Chicory	*Cichorium intybus*	Safflower	*Carthamus tinctorius*
Cowpea	*Vigna unguiculata*	Sugar Beet	*Beta vulgaris*
Eggplant	*Solanum melongena*	Tomato	*Lycopersicon esculentum*
Flax	*Linum usitatissimum*	Sugarcane	*Saccharum* sp.
Maize	*Zea mays*	Soya	*Glycine max*
Melon	*Cucumis melo*	Wheat	*Triticum aestivum*
Papaya	*Carica papaya*	Squash	*Cucurbita pepo*

Since the introduction of first GM crop for commercial cultivation in early 1990s, a large variety of GM food crops and their derived products are available as processed or unprocessed food items, food ingredients and animal feed in the world market. Some of these crop produce include potatoes, corn, tomatoes, soybean, canola, eggplant, strawberries, carrots, lettuce etc. (Table 1). Though there are a number of GM crops that are commercially available, GM salmon is approved as the only GM animal for human consumption up-to-date.

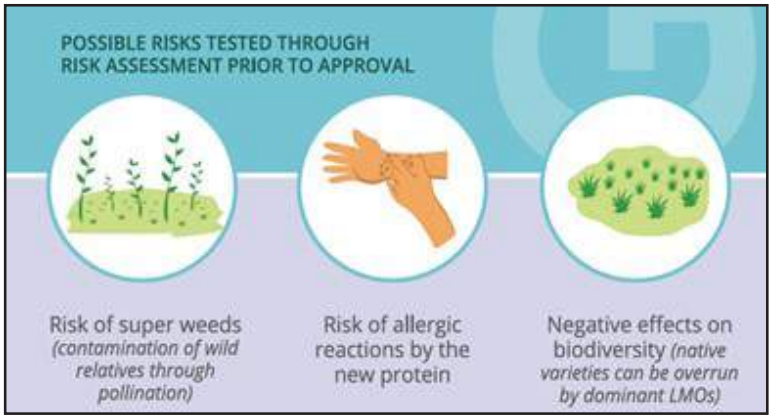
This technology has many potential applications. At present, recombinant DNA technology and GM crops are considered as promising applications in food and agriculture sectors in facing and overcoming the challenge of ever increasing demand for safe and nutritious food by mankind. Despite the growing use of genetically modified crops over the years, many including scientists appear to hold negative views about GM foods. The introduction of a gene into different cells can result in different outcomes, and the overall pattern of gene expression can be altered by the introduction of a single gene. It these outcomes become negative, will fall into two basic categories, the effects on human and animal health and the environmental consequences. Introduction of GM organisms to the natural environment has created public concerns related to biodiversity, environmental safety, food and feed safety, socio-economical and associated ethical issues. This article focuses on the major facts about GM food safety that the consumers should be aware of and how GM foods are made available to the market confirming their safety.

How Can They Become Unsafe During Development?

Consumption of GM foods by the general population should not pose any food safety risks leading to harmful health effects. The safety concerns associated with GM foods are mainly due to the possible development of hazardous molecules or compounds within the GM organisms. These hazardous materials can be either new proteins or secondary metabolites accumulated in the cells of GM organisms. The possible health risks associated with the above



hazardous compounds in the GM food crops upon consumption by human include development of toxicities and allerginicities among the consumers. The cellular mechanisms in GM organisms leading to the development of compounds with possible toxicities or allerginicities can be divided into three main categories. The first mechanism is due to the primary expression of unintentionally transferred genes in developing new proteins. The second mechanism involves secondary effects of transferred gene expression in altering cellular biochemical pathways in the host organism and insertional mutagenesis, creation of mutations of DNA resulting from gene integration is the last.



The primary products of gene expression are always proteins. The information available in the databases on the known allergenic and toxic protein producing genes in donors of desired gene traits help the scientists to get rid of such genes from introducing them into GM organisms. However, selection of genes from organisms that are previously not studied may result in transfer of hazardous proteins and lead to rejection or termination of developmental projects of GM organisms. A considerable number of examples exist as evidences of discarded GM food crops after discovering allergenic or toxic effects at different developmental stages (Domingo, 2007). In addition, foods that are frequently being reported to be allergenic such as peanut, soybean, wheat, eggs, milk, shellfish and mushroom etc. are studied thoroughly before using them as donors of selected genes. Due to the expansion of knowledge and awareness on genes with the above health considerations, early recognition of hazards in GM foods are possible.

The secondary effects of gene expression are intensively studied because, most of the proteins produced due to gene expression function as enzymes that regulate or alter cellular biochemical pathways. The new enzymes introduced to the GM organisms may express unknown or unintentional effects by modifying the expression of untargeted biochemical pathways that can accumulate new compounds with toxic or allergenic effects or trigger the production of such compounds that are naturally in existence at nonhazardous levels. These changes in metabolism can lead to an increase in toxin concentrations. Assessing of these changes in GM organisms is a challenge in genetic engineering and thus extensive research studies are carried out to investigate all associated adverse health effects.

The third mechanism of developing hazardous materials in GM foods is insertional mutagenesis that disrupts or changes the expression of existing genes in a host plant due to insertion of new genes or the DNA. Disruption of existing gene expression can be resulted due to nonspecific insertion of genes to the host organism. This will lead to the development of altered or fused proteins which are potentially of toxic or allergenic in nature. Further, insertional mutagenesis can either trigger the expression of silent genes or down regulate the expression of critical genes leading to the development of secondary toxic materials.

Though the above mentioned health related adverse effects are possible due to genetic modifications, generally they are identified at the developmental stages and addressed before releasing GM foods for human consumption. This is in line with the standard practice of removing lines of conventionally bred plants exhibiting undesirable properties during the course of a commercial selection programme. In addition, continuous market surveillance helps in early detection of any health concern targeting specific groups of consumers and ensures the implementation of mechanisms to rectify the negative effect through effective communication.

How GM Food Safety is Assured?

Safety assessment of GM food is performed mainly to assess the unintended effects of the genetic

modification, and in particular to identify whether these effects raise any food safety concerns. The safety assessment of GM foods is generally undertaken in accordance with internationally established scientific principles and guidelines. Internationally reputed organizations such as, Food and Agriculture Organization (FAO), World Health Organization (WHO), Codex Alimentarius Commision and Organization for Economic Cooperation and Development (OECD) are involved in developing such principles and guidelines. Even though strict guidelines are used in assessing safety of GM food, it does not mean that they are less safe than food produced by conventional means. Nevertheless, most of the non-GM food that are consumed today are not thoroughly assessed for their safety compared to the GM food, generally considering them as safe due to the long existence in the society.

The concept and principles of assessing safety of GM food involve a scientific comparison of the GM food to a conventional counterpart having a history of safe use, which is known as substantial equivalence. This assessment enables to develop a reasonable certainty that the particular GM food does not pose any harm to the consumer when it is processed and consumed as recommended. If the GM food is not substantially equivalent, or in other worlds if it contains unintentional hazardous material/s, it is further evaluated in relation to human health following a systematic safety assessment framework. This safety assessment procedure enables to identify the nature and the severity of the

hazard and possible measures of overcoming the risk. Moreover, intensive safety assessment focuses on the important characteristics of the recombinant gene/s, composition of the food, effects of processing and preparation, especially possible toxicities and allerginicities, etc. In this context, the possibilities of causing adverse health effects by the GM food to the consumers are considered to be very low. However, there may be special groups of individuals who are hypersensitive or susceptible to some of the new materials present in the GM foods that are non-toxic or non-allergenic to the general population. Therefore, different regulatory approaches are taken in approving the GM products for human consumption and communicating them to the consumers by different countries.

GM Food: Sri Lankan Standpoint

Similar to many countries that have approved GM food, Sri Lanka has also given the legal provision to import and consume GM food under the Food Act imposing a GM food (control of import, labelling and sale of genetically modified foods) regulation with effect from the year 2007. However, no permission is given in Sri Lanka to grow GM crops for food or feed purposes. According to the above GM food regulation, importers must obtain a prior approval to import GM food or feed to Sri Lanka, and risk analysis need to be done by the local authorities to confirm their safety. Further, if GM foods are marketed in Sri Lanka they must be properly labeled to communicate about the genetic modification to the consumer. Up-to-date no importer has obtained an approval to import GM food to Sri Lanka, thus no labeled GM food products are available in the market. With the rapid developments in the GM food industry, expansion of GM food volumes in the world market and introduction of advance techniques and tools in identifying GM food safety, it can be anticipated that GM food will reach Sri Lankan market in the future. In this context, assessment of safety of GM food becomes important to protect human health and the environment from the potential adverse effects. Several organizations are actively working in Sri Lanka to develop a system to establish biosafety of GM foods to proceed with evidence-based decision making to prevent harmful consequences.

Dr Niranjan Rajapakse (PhD)
Senior Lecturer, Department of Food Science & Technology, Faculty of Agriculture, University of Peradeniya