

WHAT IMPACT DO GENETICALLY MODIFIED (GM) FOOD HAVE ON OUR HEALTH?

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Abstract

In recent years there has been a notable concern on the genetically modified (GM) food safety. It was probably triggered by introduction of these transgenic products to the food market, resulted in them becoming a controversial topic. The aim of this systematic review was to present available data in the published articles concerning the effects of GM food on human health.

We referenced over 60 studies of GM food published in scientific journals. In spite of this clear assessment, it is worth of note that the review articles concerning toxicological, metabolic, allergenic, immunological and cancerogenous effects of GM food were surprisingly very limited. Results from most studies related on GM products such as potatoes, corn, rice and soybeans, and their effects on animal models were various, but nearly all of them reflected that they are as safe and nutritious as their non-GM counterparts.

In conclusion, some of the presented studies have been conducted by biotechnology companies responsible of commercializing these GM plants but without scientific evidence showing that GM food is safe. Finally, the choice between traditional and non-conventional food remains to be decided exclusively by the consumers.

Key words: *Genetically modified food, Transgenic food, Food safety, Public health.*

1. Introduction

In recent years there has been a notable concern on the safety of genetically modified (GM) food. It was probably triggered by introduction of these transgenic products to the food market, resulted in them becoming a controversial topic [1, 2].

According to the information reported by the WHO, the genetically modified (GM) products that are currently

on the international market have all passed risk assessments conducted by national authorities [2, 3].

These assessments have not indicated any risk to human health. In spite of this clear statement, it is quite amazing to note that the review articles published in international scientific journals during the current decade did not find, or the number was particularly small, references concerning human and animal toxicological/health risks studies on GM foods [3, and 4].

2. Genetically modified food

2.1 What is genetically modified food?

Genetically modified organisms (GMO's) are just what the name implies. Organisms, in this case foods that have been genetically altered. Genetically modified (engineered) food are presumably plants that have been generated in a laboratory by altering their genetic makeup and have been tested in the laboratory for desired qualities [5]. This is usually done by adding one or more genes in a plant's genome using genetic engineering techniques. Most genetically modified plants can be modified in a directed way by gene addition (cloning) or gene subtraction (removing or inactivation of the genes). Plants are engineered for insect, fungal, viral or herbicide resistance, for changed nutritional content, improved taste, and improved storage [6]. Once satisfactory plants are produced, sufficient seeds are gathered, and the companies producing the seed need to apply for regulatory approval of seed testing [1, and 5]. If these field tests are successful, the company must seek regulatory approval for the crop to be marketed. Once that approval is obtained, the seeds are mass-produced, and sold to farmers. The farmers produce GM crops, which also contain the inserted gene and its protein product. In some cases, the plant product is directly consumed as food, but in most cases, crops that have been genetically modified are

sold as commodities, which are further processed into food ingredients [7]. Foods with protein or desoxy-ribonucleic acid (DNA) remaining from genetically modified ingredients includes: fruits, vegetables, corn and soy products (soy proteins, flours), corn starch and starch syrups, vegetable oils etc. [7]. Foods processed using genetically engineered products includes: some sorts of cheese and animals fed with GM food, or treated with bovine growth hormone [8].

2.2 Assessment of health impact

More than 85 percent of the corn and soy grown in the United States comes from seeds whose DNA has been transformed, and those two crops play starring roles in countless processed foods, from soda to salad dressing to bread [8]. Advocates say genetically modified (GM) foods allow farmers to produce more with fewer chemicals - which means a cleaner environment and cheaper groceries for us all. But the question remains: What impact do GM foods have on our health?

The answer is, no one really knows. GM foods have been on the market only since 1994, and research on their long-term effects on humans is scarce. To date most of the studies have been done on animals; worryingly, though, some of those studies link GM foods to altered metabolism, inflammation, kidney and liver malfunction, and reduced fertility. In one experiment, multiple generations of hamsters were fed a diet of GM soy; by the third generation, they were losing the ability to produce offspring, producing about half as many pups as the non-GM soy group [9].

Despite the potential health implications, more GM foods appear each year. The Food and Drug Association (FDA) is expected to okay a fast-growing salmon in the near future, and possibly on the horizon: pigs designed to produce omega-3 fatty acids.

Some studies imply changes in the microstructures of the organisms. The study of Malatesta and collaborators [10] notifies that there is no direct evidence that genetically modified (GM) food may represent a possible danger for health. The authors investigated the possible effects of a diet containing GM soybean on mouse exocrine pancreas by means of ultra-structural, morphometrical and immune-cytochemical analyses. Their observations demonstrate that, although no structural modification occurs in pancreatic acinar cells of mice fed on GM soybean, quantitative changes of some cellular constituents take place in comparison to control animals. In particular, a diet containing significant amount of GM food seems to influence the zymogen synthesis and processing of enzymes, but no reflection of tissue damage or malfunction was found.

Krzyzowska and collaborators investigated the safety assessment of genetically modified (GM) food and possible effects upon animal and human health, also

the long-term, multigenerational influence upon functioning of different organs and systems, such as the immune system [11]. In their study C57BL/6J mice were fed for five consecutive generations with pellets containing 20% of conventional triticale grain (control) vs. pellets containing 20% of the transgenic triticale grain resistant to herbicides (experimental). The F5 experimental animals showed enlarged inguinal and axillary lymph nodes, but not spleens, and increased leukocyte counts in blood. Immunophenotyped cell suspensions derived from spleens, inguinal and axillary lymph nodes and from blood showed the significant decrease in the percentage of T cells in spleen and lymph nodes and the B cells in lymph nodes and blood of the F5 experimental mice in comparison to the control F5 mice. Immunoblotting analysis of interleukins (IL-2, IL-4, IL-10, IL-12, IL-6, and interferon IFN-gamma levels in serum showed significantly increased IL-2 levels and decreased IL-6 levels in the F5-experimental mice sera. No significant changes in the levels of immunoglobulins (IgE precisely) in sera in both mice groups were observed. The obtained results indicated that multigenerational use of feeds for rodents containing the GM-triticale leads to expansion of the B cell compartment in the secondary lymphoid organs, but it was not caused by malignant processes or the allergic response.

While some groups and individuals have called for more human testing of genetically modified food [12] there are several obstacles to such studies. The General Accounting Office (in a review of FDA procedures requested by US Congress) and a working group of the Food and Agriculture Organization (FAO) and World Health Organization (WHO) have said that long-term studies of the effect of genetically modified food on humans are not feasible [13]. The reasons given have included the problem that there is no plausible hypothesis to test, that very little is known about the potential long-term effects of any foods, that identification of such effects is further confounded by the great variability in the way people react to foods and that epidemiological studies are not likely to differentiate the health effects of modified foods from the many undesirable effects of conventional foods [14].

Additionally, there are strong ethics that guide the conduct of research on human subjects, which mandate that the intervention being tested must have a potential benefit for the human subjects, such as treatment for a disease or nutritional benefit (ruling out toxicity testing on humans) [15]. In this context, scientists and regulators discussing clinical studies of genetically modified food have written that the "ethical and technical constraints of conducting human trials, and the necessity of doing so, is a subject that requires considerable attention" [16]. Golden rice has been tested in humans to see if the rice provides a nutritional benefit, namely, increased levels of Vitamin A [17, and 18].

In 2007, the Séralini lab [19] published a paper, subsequently retracted by the journal editors [20] which looked at the long-term effects of feeding rats various levels of genetically modified roundup resistance maize, maize spiked with the roundup chemical and a mixture of the two. The paper concluded that rats fed the modified maize had severe health problems, including liver and kidney damage and large tumors. There was widespread criticism of the published study concerning that there was no control group of rats and that the selected rats were genetically predisposed of tumor growing by itself.

Published studies have suggested negative impacts from eating genetically modified food. The first such peer-reviewed paper, published in 1999, covered research conducted by Stanley Ewan and Arpad Pusztai [21]. Pusztai had fed rats with potatoes transformed with the *Galanthus nivalis* agglutinin (GNA) gene from the *Galanthus* (snowdrop) plant, allowing the GNA lectin protein to be synthesised. Lectin is known to be toxic, especially to gut epithelium [22], and while some companies were considering growing genetically modified crops expressing lectin, GNA was an unlikely candidate [22]. Pusztai reported significant differences in the thickness of the gut epithelium, but no differences in growth or immune system function. The published paper was criticized on the grounds that the unmodified potatoes were not a fair control diet and that any rat fed only on potatoes would suffer from a protein deficiency [23].

In 2013, Harrison and associates [24] have reported a study notifying that compositional studies on genetically modified (GM) and non-GM crops have consistently demonstrated that their respective levels of key nutrients and anti-nutrients are remarkably similar and that other factors such as germplasm and environment contribute more to compositional variability than transgenic breeding. Seems that GM crops are less harmful than non-GM crops treated with chemical substances such as herbicides or pesticides.

In 2009, Donna and associates [25] implies that the results of most studies with GM foods indicate that they may cause some common toxic effects such as hepatic, pancreatic, renal, or reproductive effects and may alter the hematological, biochemical, and immunologic parameters. However, many years of research with animals and clinical trials are required for this assessment. The use of recombinant growth hormone (GH) or its expression in animals should be re-examined since it has been shown that it increases Insulin Growth factor 1 (IGF-1) which may promote cancer.

The consequent reply to this study was reported by Craig Rickard in 2009 where the criticism was addressed to authors, notifying that they were not familiar with or voluntarily ignore the concept of substantial

equivalence as they did not quote equivalent key referent papers in this field and were focused on the precautionary principle approach. Namely, there were not enough key evidences of the methods required by scientific papers [26].

On the molecular level a few studies reported no harmful effect of the conventional versus transgenic food. It is worth of note the study of Azevedo and associates [27] where a mutagenic properties of conventional and transgenic soybeans have been evaluated. The 10% and 20% conventional and transgenic soybean diets on animals did not significantly decrease the frequencies of micronucleated polychromatic erythrocytes in bone marrow induced by cyclophosphamide. However the 10% and 20% conventional diets significantly ($P < 0.05$) protected nucleated bone marrow cells against chemical-induced mutagenesis and also produced a significant ($P < .05$) decrease in the total percentage of spontaneous aberrations. Among the treatments with transgenic diet, only the 10% transgenic soybean diet reduced the percentage of total aberrations induced by cyclophosphamide. The results also indicated that the treatment with 20% transgenic soybean alone significantly ($P < 0.05$) decreased the mitotic index (MI) of the cells, indicating cytotoxic effects related to the treatment. Taken together, these results suggest that, under the tested conditions, transgenic and conventional soybean have antimutagenic properties and are not toxic.

2.3 Further developments in the area of GMOs?

Future GM organisms are likely to include plants with improved resistance against plant disease or drought, crops with increased nutrient levels, fish species with enhanced growth characteristics [3]. For non-food use, they may include plants or animals producing pharmaceutically important proteins such as new vaccines [28].

2.4 The role of world health organization (WHO) to improve the evaluation of GM foods

WHO has been taking an active role in relation to GM foods, primarily for two reasons: on the grounds that public health could benefit from the potential of biotechnology, for example, from an increase in the nutrient content of foods, decreased allergenicity and more efficient and/or sustainable food production; and based on the need to examine the potential negative effects on human health of the consumption of food produced through genetic modification in order to protect public health. Modern technologies should be thoroughly evaluated if they are to constitute a true improvement in the way food is produced. WHO, together with FAO, has convened several expert consultations on the evaluation of GM foods and provided technical advice for the Codex Alimentarius Commission which was

fed into the Codex Guidelines on safety assessment of GM foods [29]. WHO will keep paying due attention to the safety of GM foods from the view of public health protection, in close collaboration with FAO and other international bodies.

3. Conclusions

- This review can be concluded raising the following question: where is the scientific approach to ensure the population that GM food is safe?

- In 2010, the European Commission Directorate-General for Research and Innovation reported that "The main conclusion to be drawn from the efforts of more than 130 research projects, covering a period of more than 25 years of research, and involving more than 500 independent research groups, is that biotechnology, and in particular GMOs, are not per se more risky than e.g. conventional plant breeding technologies.

- From our point of view, many researchers working on GM crops are in fact trying to solve important problems, such as feeding a growing population, keeping food prices affordable worldwide, making healthier fruits and vegetables widely available, confronting the challenging growing conditions of a changing climate, saving fruits and vegetables from pests, and fighting malnourishment in the developing world. For many of these problems, genetic engineering is faster, more cost-effective, and more reliable than conventional breeding methods. On the other hand, investigations concerning the human health are probably expensive even in well developed countries.

- However, because of potential for exposure of a large segment of human population to genetically modified foods, more research is needed to ensure that the genetically modified foods are really safe for human consumption.

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