GMO on our table – progress or catastrophe?

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Introduction

With regard to the new bill on seed production (by now vetoed by the President of the Republic of Poland Bronisław Komorowski) there has been an increasing number of stormy discussions on GMO, i.e. genetically modified organisms. This is due to the fact that the new act does not regulate the issue of genetically modified cultivations nor does it forbid them. It specifies the mode of registering and creating sowable material (mainly traditional varieties). The act does, however, contain a regulation pertaining to the possibility of registering transgenic varieties which stirs controversy. The following entry provokes anxiety: "Sowable material of genetically modified varieties is authorized for marketing if the modification of the variety is authorized for marketing with the purpose of cultivation based on the decision of the proper European Union body or a proper member state body" (art. 104 of the government bill on seed production). In other words, there is a danger that practically anyone would be able to buy GMO seeds in one of the EU countries in which such cultivations are legal, import and sow them. However, the above entry is contrary to the binding regulations which prohibit the trade in GMO sowing material in Poland. Moreover, for approximately one and a half years the Polish Parliament has been a place for debates on the bill titled "Law on genetically modified organisms" which does not anticipate the unconditional introduction of GMOs and their release into the environment. The status of works on the "Law on genetically modified organisms" bill lays ground for claims that GMO cultivation in Poland will not be possible, for as a result of the works of subcommittees a complete prohibition was adopted of GMO cultivations, as well as the release of genetically modified organisms into the environment.

After consultations with experts the President of the Republic of Poland has vetoed the act on seed production which contains regulations pertaining to GMO and has described it as "legal trash". The President stressed that the bill was referred by the government to the parliament "mainly with the intention of obtaining full compliance of the Polish law with EU legislation", because based on the ruling of the European Court of Justice the prohibition of trade and registration of transgenic cultivations is incoherent with EU law and this may result in high financial penalties being placed on Poland. According to the President, the most important issue is the development of a suitable "parent act on GMO from which solutions would stem (...) for all other acts such as the act on seed production" [1]. At the same time, it seems there is a large need for public debate on potential threats resulting from introducing GMO into the environment.

With regard to the existing anxieties, this paper explains what genetically modified organisms are, how they are created, what benefits they carry with them and whether scientific proof exists that we should fear the presence of GMO on our tables.

GMO – what is it?

GMOs, i.e. genetically modified organisms, are obtained using genetic engineering methods. They contain a changed genetic material which would otherwise not be created as a result of reproduction or natural recombination (exchange of genetic material). GMOs present different qualities than the initial species. These new properties are beneficial from the point of view of human beings – they lead to the maximization of crop, the reduction of cultivation and transportation costs which translates into lower prices of such food.

Since the dawn of time human beings have aimed at improving varieties of plant and animal species. However, these conventional cultivation processes involving crossing have led to obtaining only small changes in the genetic material. Modern DNA recombination techniques[1] have at their disposal a huge pool of genes[2] which may be used for creating transgenic organisms[3] of an unlimited diversity.

How are GMOs created?

Compared to traditional cultivations, modern genetic engineering methods enable a considerably faster creation of organisms with desired properties, mainly thanks to the possibility of linking a given quality with a specific gene. Before a given organism becomes genetically transformed a fragment of the genetic material has to be obtained which belongs to another organism. It may be cut from a larger DNA fragment by so-called restricted enzymes, i.e. protein particles which are capable of cutting DNA threads in a specific location, thanks to which an interesting genetic sequence is obtained. Such prepared material, referred to as a transgene, is introduced into plant or animal cells [2]. The division of methods for obtaining transgenic organisms is presented in Figure 1.

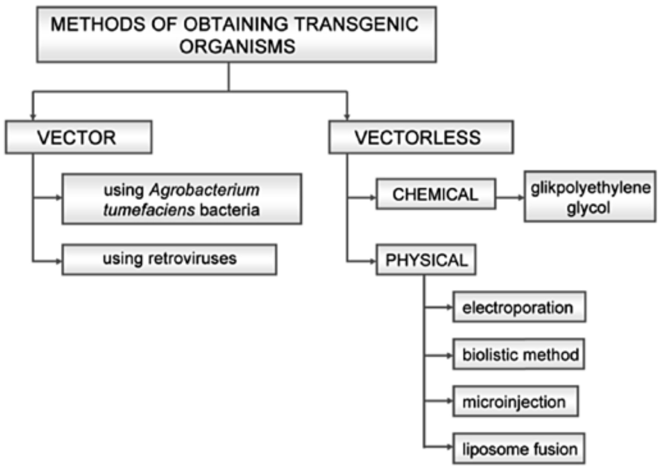

Fig. 1. Victor mediated of obtaining GMOs

In vector methods the genetic material is introduced into the target organism by means of vectors – most often bacteria or viruses.

In the genetic modification of plants *Rhizobium* bacteria are used – most often the *Agrobacterium tumefaciens* species. In the natural environment these microorganisms create a plant disease called crown gall disease. They infect through penetration into cut

[1] DNA – deoxyribonucleic acid, fulfills the role of a genetic information carrier for live organisms

[2] Gene – a fragment of DNA containing encoded information about the structure of a specific protein, hereditary unit

[3] Transgenic organisms – organisms which in their own genetic material contain foreign genes from another organism

tissues. *Agrobacterium tumefaciens* bacteria contain plasmid in their cell[4] which carries encoded information about proteins necessary for infecting a plant. It is transferred into the plant cell and its fragment, called the T

(T-DNA) segment, integrates with the genetic material of the host's cell. It is possible to remove genes located inside the T fragment and to substitute them with any DNA fragment which contains genes from another species [3].

During the genetic modification of animal cells transgene is carried by, among other, retroviruses (viruses containing RNA instead of DNA) which are used to infect cells in the early stage of embryonic development [2].

The second group of methods which allow for obtaining GMOs are called vectorless methods and involve the direct introduction of DNA into plant or animal cells [4, 5]. Vectorless methods have been divided into physical and chemical. The first group includes:

- electroporation – involving the application of a series of electric impulses which disturb the membrane structure leading to the creation of pores through which DNA permeates into the cell
- particle bombardment which uses microscopic gold or tungsten pellets of a 0.5 – 5 μm diameter and DNA coating that is to be introduced into the cell. Such prepared genetic material is fired into plant cells using a so-called *particle gun*
- microinjection – involving the manual introduction of DNA using a micromanipulator needle. This technique is used for creating transgenic animals liposome fusion – which uses the capability of liposomes to organize into a bilayer. The shaking of lipids with genetic material leads to creating vesicles – liposomes containing DNA. Merging with cell protoplasts, liposomes introduce DNA which is the object of genetic manipulation.

The vectorless chemical method involves the use of polyethylene glycol which increases the cell membrane's permeability as a result of its short-term and reversible disorganization. This allows for avoiding the permeation of the transgene into cells, together with the carrier DNA [6].

Should we fear GMOs?

According to the majority of scientists there is no evidence pointing to the negative impact of GMO food on the human body. Few results indicating the harmfulness of eating GMO food have not been verified in studies conducted by independent laboratories. Moreover, in the entire scientific literature only a few reports provide information on the health threats related to GMO consumption. They are juxtaposed with a huge amount of scientific resources which prove that transgenic food is safe. This is the official position of the European Food Safety Authority (EFSA), the Food and Drug Administration (FDA) in the US and the Food and Agriculture Organization of the United Nations (FAO), as well as the European Commission. It is based on the results of 81 scientific programs which cost half a billion EUR [7].

The enthusiasm linked with GMOs is abated by reports on allergic reactions caused by consuming GMO products. The introduction of new genes usually means the occurrence of new proteins, sometimes allergenic, which are not present in natural varieties. Furthermore, increasing the content of a specific protein in "new food" as a result of genetic modifications may cause an allergic reaction despite the fact that traditional food containing the same protein in small amounts does not induce such effects. Clinical allergy symptoms occur with different intensity – from skin changes, through digestive tract disorders, up to an improper functioning of the respiratory and cardiovascular systems as well as anaphylactic shock. An example of allergy caused by GMO consumption is soya containing a gene from the Brazil nut which encodes methionine-rich protein[5]. Studies have shown that people allergic to Brazil nuts are also allergic to genetically modified soya [8]. However, many traditional food products also cause allergies. GMOs undergo huge amounts of tests before they are released into commercial markets.

Many fears appear also with regard to the possibility of losing control over transgenic cultivations. The opponents of GMOs fear that the introduction of herbicide[6] -immune varieties into fields will lead to the creation of "superweeds" because plants cross with one another and people may not control this process. Pollen of modified plants may cross with certain wild-growing plant species, even over a large distance. This may lead to transferring immunity genes onto pesticides and weeds which will lead to creating the above-mentioned "superweeds", immune to applied chemical agents. This will cause the increase of the amount of pesticides introduced into the environment and such chemicalization increase of cultivations may bring about side effects involving eliminating part of wild flora which constitutes an ecologically essential element of the environment, ensuring food and shelter to insects and birds. However, it should be pointed out that in Europe only modified corn and potatoes may be cultivated. Potatoes are reproduced from seed-potatoes and their crossing with other plants does not pose any threat. On the other hand, corn may pollinate only another corn; however, even if that happened the seed would not last through winter and the changed plants would not grow [7].

Another threat related to the introduction of transgenic plants for field cultivation is lowering the level of biodiversity, i.e. the diversity of forms and structures which create varieties, species and breeds. Biodiversity provides the chance to adapt to changing environmental conditions and it constitutes protection in case of a disaster or plague. Monocultural unification of cultivations as well as the decrease of the amount of varieties poses threat to the extinction of the species in case an unfavorable factor attacks. It should be mentioned that, according to the FAO report, by entering into the 21st century we have lost 95% of genetic diversity which existed in agriculture at the beginning of the 20th century. For example, in 1949 8,000 varieties of rice were grown in China (currently only 50), while in USA 7,300 vegetable varieties were destroyed within 80 years [2].

To sum up, the biggest anxiety in scientists is provoked by the inability to anticipate multigenerational effects [7]. Since the introduction of the first genetically modified organism into the market, i.e. since 1994 when Flavr Savr® tomatoes were authorized for marketing in USA, few cases were noted which pointed to the harmfulness of GMOs and which required more reliable and documented confirmations. However, we are not able to anticipate the long-term impact of GMOs on human health and the environment.

GMO – what can we gain?

Undoubtedly, the possibilities of genetic engineering are huge. Thanks to genetic modifications plants are obtained which are immune to diseases caused by fungi, viruses and bacteria; their tolerance to herbicides is growing, they are becoming immune to insects – vermin and unfavorable environmental conditions (drought, frost, salinity) [2, 9÷12]. The types of genetic modifications of plants, applied methods and examples of modified organisms are listed in Table 1.

Genetic modifications of plants are used for improving qualitative features: nutritious values, life, color, smell and aroma. Examples of transgenic plants with changed properties are listed in Table 2.

4 Plasmid – a small, usually circular DNA molecule which occurs mainly in bacteria cells and encodes antibiotic-resistant genes, capable of independent replication

5 Methionine – sulphur-containig amino acid, a protein constituent, essential for human life.

6 Herbicides – weedkillers

Table 1

Types and applied methods of genetic modification and GMO examples

Modification	Modification Method	Examples
immunity to fungi, viruses, bacteria	introducing enzyme-encoding genes which destroy the cell wall or coat protein of pathogens	tobacco immune to tobacco mosaic virus (TMV), potato immune to X,Y virus and leaf roll virus, cucumber immune to cucumber mosaic virus, cauliflower immune to cauliflower mosaic virus, peanuts immune to peanut stunt virus, apricot and plum immune to pox virus
immunity to herbicides	introducing enzyme-encoding genes which decompose herbicides	soya, corn, rape, tobacco, tomatoes
immunity to insects – vermin	introducing a gene from the *Bacillus thuringiensis* bacteria, which encodes toxic protein (Bt), paralyzing insects' digestive tract	Bt corn, variety MON 810 of Monsanto – immune to larvae of the European corn borer (*Ostrinia nubilalis*)
immunity to frost, high temperature, drought, soil salinity	introducing genes which encode proteins immune to denaturation	potato immune to frost thanks to the introduced gene of the Arctic flounder

Table 2

Selected transgenic plants with improved properties

Plant	Effect of genetic modification
tomato	delayed maturing and softening (FlavrSavr® – first GMO introduced for sale), improved taste, intensive color, thinner skin
wheat	increased gluten content (improvement of flour quality)
grapes	seed-free varietes
strawberry	increased sweetness of fruit, delayed maturing process
rice	transgenic variety with daffodil genes – improved production of β-carotene, the precursor of vitamin A (solving the problem of the lack of vitamin A in children from East Asia)
potatoes	increase of starch content, low content of harmful substances (e.g. solanine)
celery	improved brittleness
soya	oil with a lower content of palmitic acid
coffee	lowered content of caffeine (up to 70% less than usual)
tobacco	varieties containing 20 times less nicotine and 15 times less carcinogenic substances than traditional varieties

English scientific literature often mentions the term "molecular farming", i.e. the production of biopharmaceuticals using genetically modified plants. One example is modified lettuce producing a hepatitis B vaccine which was developed by scientists from the Institute of Bioorganic Chemistry of the Polish Academy of Sciences in Poznań [13].

Modifications of animals are not as popular as in the case of plants, mainly because of the difficulties in the very transformation process – it is complicated, long-term and costly. The purpose of conducted modifications is especially to obtain specimen of desirable qualities in cultivation – which achieve a higher body mass quicker, characterized with a higher milk efficiency or immunity to a specific disease. Transgenic farm animals are created also with the aim of their using as bioreactors which produce changed proteins of pharmaceutical significance. This way it was possible to create transgenic sheep, goats and cattle producing: antitrypsin used in treating emphysema and other pulmonary diseases, a clotting factor, erythropoietin treating anemia, interferon battling viral infections and cancer as well as growth hormone which regulates this process [2].

Summary

So far negative effects of consuming transgenic food are not broadly known; however, we do not have long-term, multigenerational studies on the impact of GMO on the environment and human health. The subject of GMO arises numerous controversies and there is a need for a reliable, scientific debate which will objectively present the benefits as well as the potential risk of consuming genetically modified food. It seems important to approach the issue of GMO rationally, based on caution standing from the Cartagena Protocol on biological safety [14], propagating the sentence that it is better to prevent negative phenomena than to undertake corrective measures after their occurrence. Thus, what is important is the openness of experiments which lead to creating GMOs. Moreover, it is necessary to mark food containing transgenic organisms. According to the currently binding law, in Poland products containing over 1% in mass of genetically modified elements must contain suitable information on the package. It is not required (something that GMO opponents are aiming at) for, e.g. ham from a pig fed with genetically modified soya to have similar markings. The consumer must have a guaranteed right to choose between modified and "clean" food as well as to be informed about the potential threats resulting from the consumption of such products so that his actions are based on facts and not prejudices resulting from the lack of knowledge.

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