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TRANSGENIC PLANTS – GENETICALLY MODIFIED FOOD

Key words: transgenic plants, genetically modified food, crop acreage

Introduction

The turn of the XX and XXI centuries is the time of the greatest accomplishments in the field of molecular bases of life as well as dynamic development of genetic engineering and biotechnology. Biotechnology has been commercially utilised, among others, in medicine and environmental protection. Methods of genetic engineering are gaining particular significance in food production and processing (agrobiotechnology), that in the near future are likely to predominate the world food market (Tomkiewicz and Zając 2007).

Since commercialization of the first cultivars of genetically-modified plants in 2006, their global acreage is still increasing. According to recent data, thousands of genetically-modified plant lines have been tested, out of which cultivars of, among others, corn, tomato, rice, soy, strawberry, or grapevine were introduced to the cultivation practice. As a result, most of corn, cotton and soy crops in the USA are transgenic. Nowadays, we have reached the crucial stage for the future utilization of genetically modified plants (GMP) (Zimnoch-Guzowska et al. 2004). A worldwide social discussion is being held about direct usage of that new generation of plants in the food production. Consumers are anxious mainly about the health aspects of the intake of genetically modified food, for example: soy and corn with bacterial genes, tomato with fish genes, potato with jellyfish genes, rice or carps with human genes, or lettuce with rat genes, as their long-standing effects on human body have not been explicitly recognized yet.

The aim of the study was to present the fundamental issues concerning genetically modified plants and food.

Transgenic organisms, transgenic food

According to the Art. 3 of the Act of the 22 June 2001 on *Genetically Modified Organisms* (Official Journal of 2001, No. 76, Item 811, with later amendments): **Genetically Modified Organisms (GMO)** or **transgenic organisms** are organisms other than humans, whose genetic material has been altered in a way that does not occur naturally by crossing or natural recombination.

Modifications organisms are subject to may be divided into three groups:

- a) activity of genes naturally present in an organism is altered,
- b) additional copies of genes are introduced into the same organism which they originated from,
- c) introduced gene originates from other organism.

The field of science dealing with modifications of organisms is **genetic engineering**. It enables the isolation and replication of any gene from any organism and its insertion into a genome of a modified organism using various methods. The transferred gene is called **transgene** – and that is from where the term **transgenic organism** was derived. After being transferred – the **transgene** is permanently included into the genome of a host organism and since then is present in all descendant organisms (www.biotechnolog.pl/gmo-3.htm).

Genetically modified food or **transgenic food** is food derived from genetically modified plants or animals. Those products consist of genetically modified organisms (GMO) or their parts (Azevedo and Araujo 2003). Transgenic food, in comparison to the traditional food, may possess new features, such as: changed functionality, nutritional value, health-promoting, technological or sensory characteristics (Grajek 2006, Kolodinsky *et al.* 2004).

The achievements of genetic engineering affect, among other things, the improvement of food flavor and create organisms which support therapy of some diseases. The aim of genetic scientific research is to create plant organisms resistant to weather conditions, pests, herbicides and producing a high crop yield (Tab. 1). Those products are supposed to reduce cultivation costs and eliminate the global starvation problem. However, GMO products have sparked significant controversy. The most serious problem is connected with the fact that it is still difficult to predict how the intake of those foods may influence a human organism (Kosicka-Gębska and Gębski 2008).

Genetic modifications which provoke the greatest controversy are introduction of genes originating from other species that give a desirable trait to the modified organism, which does not occur naturally. The effects of agrobiotechnological methods of cultivation are more and more noticeable.

Their products are present on global markets. For example, transgenic tomato resistant to diseases has been grown in USA since 1995. Since 1997 transgenic potato resistant to viral infections has been produced and transgenic soy, rapeseed and cotton have been grown since 1998. Effects of genetic improvement of many other plants are known as well. In this way, apple tree resistant to insects; maize, cabbage and wheat resistant to herbicides were obtained. Transgenic coffee bush produce more beans which yield improved taste and enriched aroma to coffee made of them. Bananas resistant to fast rotting and vegetables with increased vitamins content are known as well. These are only a few examples of plants, whose functional traits mentioned, obtained by means of biotechnology, are replicated in next generations, thus becoming permanent traits of an organism and predisposing it for commercial cultivation. An important research direction of **agrobiotechnology** is also introduction of transgenic plants to the production of oral vaccines, for instance against AIDS, viral hepatitis B and rabies. Studies on the utilization of those plants as renewable resources in biorefineries are also undertaken (www.futurum.biz.pl/futurum_art/pl_art_1.htm).

Tab. 1. Selected transgenic plants.

Plant	Effect of genetic modification
Strawberry	increased sweetness, delayed ripening, freeze resistance
Apple tree	resistance to insects
Bananas	resistance to viruses and fungi, delayed ripening
Grapevines	seedless varieties
Celery	increased tenderness
Broccoli	delayed ripening
Chicory	increased sugars content
Cabbage	resistance to pests, smaller head size
Pumpkin	resistance to fungi and insects
Tomato	higher content of dry matter, delayed ripening and softening, better taste, more intensive colour, thinner peel, resistance to viruses and infections
Soy	resistance to herbicides, reduced palmitic acid content of oil
Rapeseed	increased laurylic acid content, reduced content of unsaturated fatty acids of oil
Potato	increased starch content, cyclodextrins production, resistance to darkening after injury, amylopectin starch, low glycoalkaloids content, low reducing sugars content, resistance to viruses, resistance to potato beetle
Wheat	resistance to herbicides, increased gluten content
Coffee	better aroma, higher yield, reduced caffeine content
Sunflower seeds	reduced unsaturated fatty acids content

Source: www.laboratorium.elamed.pl/strona-numer-9-2007-3835.html.

EU and Polish government policy towards GMO food

According to Regulation (EC) No 1829/2003 of the European Parliament and of the Council, if food material contains more than 0.9% of GMO it should be labelled as “genetically modified food”. The label on the package: “genetically modified food” means food which contains, consist of or is produced from GMO. „Produced from GMO” means products derived, in whole or in part, from GMO. The labelling should include objective information that food contain, consist of or is produced from GMO. In addition, the labelling should give information about any characteristic or property which renders modified food different from its conventional counterpart with respect to composition, nutritional value or nutritional effects, health implications as well as any characteristic or property which gives rise to ethical or religious concerns (Zimny 2007). Due to Polish aspiration to be GMO free country, the Polish government allows only the import of GMO food from outside the European Union and from Member States of the EU **on condition that it is clearly labelled and not further processed in Poland** (O. J. 2005, No 31, item 265 uniform test). Tab. 2 presents the list of GMO plants approved for market turnover by the EU, as well as notified and pending.

The State Sanitary Inspector is responsible for the introduction of GMO to the food market in Poland, according to Regulation No 1829/2003 of the European Parliament and the Legal Act of 11 May 2001 on health conditions of food and nutrition (O. J. 2005, No 31, item 265 uniform text). The Polish government supports only works on contained usage of GMO according to regulations of law (O. J. 2002, No 107, item 944). According to the Legal Act of 23 June 2003 on seed material (O. J. 2003, No. 137, item 1299) and the Directive 2002/53/EC, the Minister of Agriculture is responsible for registration of crop varieties, including the genetically modified plants. At the EU level, there are no binding legal regulations regarding the cultivation of genetically modified plant growing and coexistence of three systems of agriculture – traditional, organic and agriculture that use transgenic plant. Only fragmentary regulations exist in the form of instructions of the European Commission.

Tab. 2. GMO plants approved for market turnover by the EU (APP), notified (NTF) and pending (PED).

Organism	New trait	Food application	Applicant	Legal status
Corn	tolerance to insects and herbicides	food products and their ingredients	Ciba-Geigy, Novartis Seeds	APP
Soy	tolerance to herbicides	food products and their ingredients	Monsanto	APP
Canola	tolerance to herbicides	processed oil	AgrEvo UK, Plant Genetic Systems, Monsanto, Hoechst Schering	NTF
Corn	resistance to insects	food ingredients	Monsanto, Pioneer Overseas Corp	NTF
Corn	resistance to herbicides	food ingredients	AgrEvo	NTF
Tomato	delayed ripening	tomato pulps	Zeneca	PED
chicory (red - radicchio and green)	tolerance to herbicides and male sterility	vegetable	Bejo-Zaden	PED
Soy	high oleic acid content	oil	E I DuPont Nemours	PED
Corn	tolerance to herbicides	food products and their ingredients	Monsanto	PED
Soy	tolerance to herbicides	seeds	Plant Genetic Systems	PED
Corn	tolerance to herbicides and insects	vegetable, frozen sweet corn and powdered corn, food ingredients	Novartis Seeds, Monsanto, Pioneer Overseas Corp	PED
Sugar beet	tolerance to herbicides	sugar, food ingredients of pulp	Monsanto & Novartis Seeds	PED
Corn	tolerance to herbicides and insects	vegetable, frozen sweet corn and powdered corn, food ingredients	Pioneer Overseas Corp, Mycogen Seeds	PED
Mangold	tolerance to herbicides	animal feed	DLF-Trifolium, Monsanto, Danisco	PED
Potato	changed starch composition	starch and ingredients	Amylogene	PED
Cotton	tolerance to herbicides or insects	usage like other cotton	Monsanto	PED

Source: www.ift.org/govtrelations/biotech.

Selected Polish legal acts and regulations referring to GMO

1. The Act of 22 June 2001 on Genetically Modified Organisms (Official Journal of 2001, No. 76, Item 811, as amended).
2. The Regulation of the Minister of Environment of 8 July 2002 setting out how risk assessment should be conducted. This includes the assessment of risks to human health and the environment stemming from activities involving the contained use of GMOs, the deliberate release of GMOs into the environment, the placing of GMO products on the market, and the requirements which should be satisfied by the documentation containing the results of such an assessment (O. J., No. 107, item 944).
3. The Regulation of the Minister of Environment of 21 February 2002 on the detailed rules of procedure for the Commission on genetically modified organisms (O. J. 2002, No. 19, item 196).
4. The Regulation of the Minister of Environment of 6 June 2002 laying down the formats of application forms for consent and authorisation of activities involving GMOs (O. J., No. 87, item 797).
5. The Regulation of the Minister of Finance of 19 April 2002 laying down the list of Customs Offices suitable to import and export GMO products GMO (O. J., No. 43, item 406, as amended).

Transgenic crops acreage

In 2008, in the Member States of the EU, the acreage of genetically modified crops has decreased by 2% (Tab. 3). This decrease was mainly due to a ban on GMO crop implemented in France. In 2007, France was the second largest transgenic plants producer in Europe. In 2008, transgenic crops were planted in seven EU countries, among which Spain had the largest acreage. Over the last year, crop acreage increased in Poland, Czech Republic and Slovak Republic (<http://rolnicy.com/uprawa-roslin>).

European countries constrain wider introduction of genetically modified plants into agricultural practice, whereas on other continents the production of those plants is raising dynamically. In 2008, the largest producers of transgenic plants were: USA, Canada, India, and China (Fig. 1).

From the report of the International Service for the Acquisition of Agri-biotech Applications (ISAAA) titled "Global Status of Commercialized Biotech/GM crops 2008", it can be concluded that 13.3 millions of farmers from 25 countries planted 125 million hectares to genetically modified plants in 2008. Egypt and Burkina Faso initiated the most significant transgenic plant crops in Africa. In 2008, in Egypt 700 hectares were seeded with genetically

modified corn, and in Burkina Faso 8500 hectares were sown with cotton Bt. Those countries joined the Republic of South Africa, which since 1998 takes profits from the cultivation of such transgenic crops as: cotton, maize and soy.

Tab. 3. Acreage of transgenic crops in the European Union (ha) in the years 2007-2008.

Country	2007	2008
Spain	75148	79269
France	21147	0
Czech Republic	5000	8380
Portugal	4500	4851
Germany	2285	3173
Slovak Republic	900	1900
Romania	350	7146
Poland	320	3000

Source: Ministry of Agriculture / Agra Europe/ <http://rolnicy.com/uprawa-roslin>).

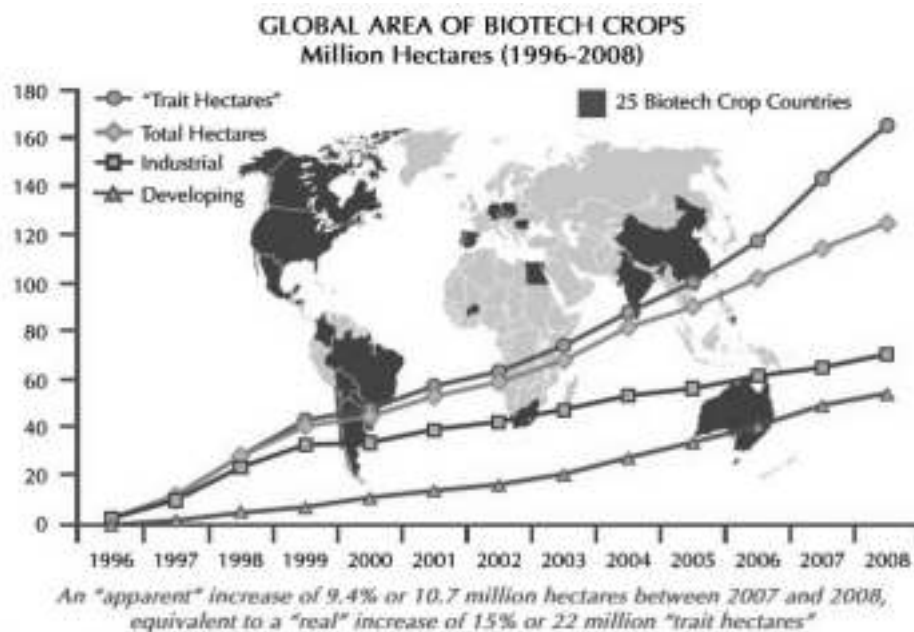


Fig. 1. Global acreage of GMO (mln ha), in the years 1996-2008.

Source: James Clive, 2008.

Summary

GMO food is food with enriched nutritional value and improved functionality (Zimny 2007). Introduction to the market and popularization of genetically modified food is an issue which has sparked a great controversy. On the one hand, the cultivation of transgenic plants may bring many benefits, e.g. increase in crop yield and quality, simplified weed, pests and disease control, however, there are fears that it may pose some risks (Praczyk 2002).

Results of a questionnaire survey conducted by Tomkiewicz and Zając (2007) confirmed far-reaching caution of consumers towards transgenic food, both because of its potentially detrimental effect on environment as well as detrimental health effects of GMO food consumption, especially by children (60% of the respondents). According to those authors, philosophical and religious beliefs can have a significant impact on consumer's attitude to genetically modified products (Zając and Tomkiewicz 2007). On the other hand, Kosicka-Gębska and Gębski reported that respondents' knowledge on GMO food is at a relatively low level. More than 60% of the respondents heard about that type of food, but were not able to explain the heart of the matter (Kosicka-Gębska and Gębski 2008).

The greatest concerns are, however, raised by the detrimental effect of GMO products on human organism. Proteins, that are products of transgenes expression, are believed to be able to modify the course of cell metabolism and lead to the formation of harmful compounds, inducing a number of diseases, allergies *etc.* Those concerns are well-founded, because cases of rash have been reported after consumption of GMO products. However, the truth is that many traditional food products also do cause allergies. In turn, the GMO food is thoroughly analysed before it is approved for sale. No detrimental effects of genetically modified food on human organism have been noted until now. However, it has never been proved explicitly that it is completely harmless, either. Effects of long-standing consumption of GMO are still unknown. Thus, discussion over this subject will surely be carrying on (www.biotechnolog.pl/gmo-8.htm).

Conclusions

1. The global transgenic plant acreage is still increasing, whereas the EU policy on the idea of GMO is very strict.
2. Doubts over utilisation of GMO in agriculture and food production result, among others, from a lack of information about the essence of new technologies and their relationships with the previously applied cultivation techniques.

3. Cooperation of experts from various fields and continuous scientific research on products of genetic engineering are necessary.
4. The results indicating no negative effect of GMO products on human health would contribute to their wider acceptance among communities.

Abstract

The analysis of changes undergoing in plant production and food industry enables concluding that food production in the XXIst century will additionally be based on genetically modified organisms. The article reports on general ideas concerning genetically modified organisms, selected transgenic plants and crop acreage planted to genetically modified plants in Poland and world wide. The government policy on transgenic food is analysed as well.

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