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TECHNOLOGICAL REVOLUTION CAUSED BY GENETICALLY MODIFIED ORGANISMS

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ABSTRACT: Biotechnology is a source of research and studies used both for animal and vegetable production and currently, known of its importance and application, there is no precedent in continuing the advances and research without this fundamental tool with support from society and several public and private organizations. The work makes reference to the importance of the agricultural and cattle raising products, their evolution and use, not only as food, but as auxiliary of human health through biotechnology, reporting requirements, products and researches that lead us to reflect on the efforts and results already attained, and goals to seek for this branch of genetic engineering.
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1 INTRODUCTION

Biotechnology is a source of research and studies used both for animal and vegetable production. If we take as example primitive techniques involving plants, animals and microorganisms, we will see that biotechnology based on transgenics is a millenary or even pre-historic branch of knowledge. Besides this, even before the discovery of genetics, fermentation processes used in the production of cheeses, wines, breads and yogurts already used rudimentary forms of biotechnology.

According to Lerayer (2010), transgenics are nothing less than the evolution of the millenary techniques. For Jean-Pierre and Kintz, (2010) they are common in agriculture since the origin of civilization, when man started to domesticate the animals and started a primitive agriculture. The intention of genetic improvement had the purpose of seeking among the species, those having the best characteristics, in order to force the predominance of that more productive, resistant, tasty, attractive species.

A genetically modified organism (GMO) is a living organism (plant or animal organism), whose genetic heritage (genome) was artificially modified, in this case, by the use of genetic engineering tools. The techniques used to modify an organism by transgenesis consists in inserting in its genome one or more additional genes from a donating organism, usually from another species. For example, if a fish gene is introduced in strawberry, the strawberry is a GMO, or, if a bacteria

gene is introduced in corn, the corn becomes a GMO. These individuals are also called transgenics, because they host the distinct genes derived from the donating organism (JEAN-PIERRE; KINTZ, 2010).

According to Jesus et al. (2006 apud CREMONESI, 2009), despite the growing employment of biotechnologies for the production of food, its potential is still repressed due to public perception issues and their consequent influence in the legislation.

Despite the fast diffusion of transgenics, studies capable of providing conclusive scientific answers as to the environmental and economic advantages and disadvantages of cultivating transgenics are still scarce.

Concomitantly with the studies of food safety, answers are necessary to ensure the safety of the genetically modified products towards the environment, since, according to Pessoa (2007 apud CREMONEZI, 2009) there is a general concern that transgenics must have a stricter evaluation to minimize the possible environmental and health hazards, due to the fact that they are obtained by an innovative process and without the familiarity of the conventional methods. Scientific methods must be used in the detection of the environmental, food, economic and social effect of these organisms with potential to cause negative environmental impact, even before field tests are accomplished.

The study of these possible influences could be made employing Environmental Impact Assessments (EIAs), which are defined as procedures for the prediction, analysis and selection of technologies, projects and development policies that minimize negative changes in environmental quality (EGLER, 2001; ALMEIDA; BASTOS, 2002; CREMONEZI, 2009). In view of the problem of nonexistence of methodologies in Brazil having the purpose of environmental and food impact analysis of Genetically Modified Plants (GMPs), the development of this kind of work could provide researchers from the academy and the productive sector a less subjective and more transparent process than the current safety evaluation procedure of the GMPs in Brazil. The development of this methodology represents a methodological advance in the sense of minimizing the uncertainties generated due to the concerns of the society in relation to the genetically modified organisms, from the moment in which the information about the impacts of this technology are available.

The unfolding of alimentary impact in the population's quality of life, based on a discerning query to specialists, will allow elucidating relevant questions related to the environmental impacts of the transgenics technology and the use or destination of its products (CREMONEZI, 2009).

The scope of this research is to divulge the importance of the genetically modified agricultural products, in which genetic engineering allowed modifying the genome both in plants, as well as in animals.

2 DEVELOPMENT

2.1 GENETIC EVOLUTION IN AGRICULTURE

Farmers have been for a long time promoting artificial selection. Azevedo (2000 apud FINUCCI 2010) states that since the start of agriculture around ten thousand years ago, human populations have used empirical methods of genetic improvement, which mimic the natural evolution processes. The domestication of wheat, barley, pea and lentil dates around seven thousand years before Christ (B.C.). Banana, apple, potato, corn, sorghum and many other vegetable cultures started to be improved as of 5,000 B.C. Others like pineapple, certain greenery, strawberry, the rubber tree and the oil palm, were in turn improved in the Christian era. With the discovery of new scientific techniques, rational methods of genetic improvement started to be used by the geneticists in cultivated plants, domestic animals and useful microorganisms like those involved in the production of antibiotics, vitamins, enzymes and other products.

In the 20th century, man started to change the plants within their cells, manipulating their genes, and not only making a selection of species that had the best characteristics. The scientists discovered the possibility of changing parts of the plants, changing their deoxyribonucleic acid (DNA), obtaining genetically modified species with different characteristics from the species from which they descended. With this, new species were created with totally different characteristics (FINUCCI, 2010). Transgenic plants, animals and microorganisms have been produced into species with commercial value, especially as of the 80s. The first transgenic plants were used in China in the beginning of the 90s. In the United States, the first approval for commercial use of a transgenic plant occurred in 1994, when company Calgene launched a tomato with high storage resistance, according to Guerrante (2003). Chart 1 presents a brief timeline of the important happenings of genetics.

Chart 1 – Genetic Evolution Timeline in Agriculture (Source: James, 2004 and Guerrante, 2003).

Date	**Occurrence**
10,000 B.C.	Empiracally made genetic improvement.
7,000 B.C.	Domestication of wheat, barley, pea and lentil.
5,000 B.C.	The first improvements appear in banana, apple, potato, corn, sorghum and other vegetable cultures.
Start of Christian Era	Improvement of pineapple, greenery, strawberry and oil palm cultures.
1663	Robert Hooke discovers the vegetal cells in England.
1796	Edward Jenner discovers in England viral vaccine against smallpox.
1830	Proteins are discovered.
1855	Thomas Escherich discovers in Germany the *Escherichia coli* bacteria.
1863	Gregor Mendel discovers genes.
1919	For the first time the biotechnology terminology is used by an engineer in Hungary.
1928	Alexander Fleming discovers Penicillin in England.
1944	DNA is discovered by Oswald Avery.
1954	Cell cultivation techniques are developed.

1970	Werner Arber, Daniel Nathans and Hamilton Smith identify restriction enzymes.
1975	Asilomar Conference, in California: concern with the biosafety of the GMO experiments.
Start of the 80s	Transgenic plants, animals, microorganism are produced in species of commercial value.
Start of the 90s	First transgenic plants are used in China.
1994	First approval for commercial use of a transgenic plant in the USA.
1998	Experimental planting of GM cultures approved in Brazil in 48 areas.
1999	Transgenic vegetables in the whole world are around U$ 2 billion
2002	Dolly sheep.
2010	Estimate of around U$ 25 billion of transgenics cultivated in the world.

2.2 CONCEPT OF GENETICALLY MODIFIED ORGANISMS (GMO)

GMO are organisms created by means of the transfer of genes from one living organism to another, usually between different species. To modify an organism, a package of genes is introduced, together with a certain genetic sequence that serves to activate another gene of interest (that could make a plant to be resistant to a certain herbicide or produce a toxin) and the DNA of the terminal sequence, which indicates where the genetic package will end (FINUCCCI, 2010).

Tersi (2011) attests that the manipulation of the genetic material in artificialized media found in specialized labs allowed for new concepts to be developed like that of biotechnology, genetic engineering, transgenics and others.

Biotechnology among many definitions could be understood as the technique of using something alive to obtain a useful product, according to the United Nations Food and Agriculture Organization – FAO (2010 apud TERSI, 2011,p.42). Thus, biotechnology is a technical process of changes in the genes of a certain living being, being important to highlight that this process would not be possible by natural means, and the purpose of all this change is functionality, perfection, efficiency, effectiveness. All these modifications in the genes of living beings are made through genetic engineering, also identified as the recombinant DNA technique and, as of the discovery and application of the recombinant DNA technique, which made it possible to combine genes of different species, like the transfer of genetic material of animals to plants, and vice-versa, which under normal situation would be incapable of sexually reproducing (TERSI, 2011).

2.3 GENETIC IMPROVEMENT VERSUS GENETIC MODIFICATION

According to Riechmann (2002 apud TERSI, 2011, p.45) genetic improvement is a technique that performs crossings within the species itself, such as, for example: corn with corn, pea with pea, as long as these species have the natural capacity of reproducing sexually. It could be mentioned that this millenary technique, common in agriculture since the beginning of civilization,

had as purpose the genetic improvement with the objective of finding among the existing species the most attractive, tasty, resistant and productive such that through this selection the species that presented the desirable characteristics would be predominant (TERSI, 2011).

Natural selection had its highlight through experiences made by the Austrian abbot Gregor Mendel, in 1856, known as the father of genetics. He developed experiences in his convent with hybridization of peas. After ten years of studies, Mendel obtained results to base laws related to hereditariness of the dominant and recessive characters.

Genetic improvement is a technique used by farmers and animal raisers for centuries, based on choosing the best specimens of each race or type of plant and crossing them between themselves, thus creating animals and plants which are bigger or more resistant to the climate or certain plagues. When selecting reproducing animals or seeds in a population to reinforce a certain characteristic of economic interest, like productivity, color or size, the producers are performing genetic improvement, technique which has been modifying the appearance and composition of food along the years. Genetic modification, in turn, is the technique of creating GMO, when gene packages of one species are attached to another to highlight a desirable characteristic, such as, for example, resistance to plagues (FINUCCI, 2010).

Generic modification consists in the transformation of the genetic information bases, where the inclusion of the genetic codes of sexually non combining species occurs, causing a genetic change that would naturally be improbable of occurring. Currently, transgenic foods are produced with this transgenesis technique. Riechmann (2010 apud TERSI, 2011, p.45) states that food is:

a) organisms used as food and which have been subjected to genetic engineering processes;

b) food with an ingredient or additive derived from an organism submitted to genetic engineering; and,

c) food produced using in its process an auxiliary product created by means of genetic engineering. Equally, this food could be originated from a vegetable, animal, directly consumed by man, i.e., when he feeds from the transgenic organism itself, and indirectly by means of ingestion of meat from an animal that was fed with ration produced with basis on transgenic vegetable or which suffered some application of vaccine containing transgenic element.

Chart 2 – Comparison between Genetic Improvement and Genetic Modification (Source: GREENPEACE, 2006).

GENETIC IMPROVEMENT	**GENETIC MODIFICATION**
Combination of genes from the same species.	Hundreds of pairs of bases (least unit of genetic code) are changed.
Selection of individuals within the same species.	Changes of biochemical processes.
Sexual crossing allows the change of characteristics.	Insertion of exogenous genes.
Natural or induced mutations change few pairs of bases.	Changes that would never happen in nature, breaking the sexual barrier.

2.4 ADVANTAGES AND DISADVANTAGES

According to Pessoa; Carvalho; Pereira (2007 apud CREMONEZI, 2010) transgenic agriculture was initially developed with agronomic attributions of resistance to herbicides and insects, with the purpose of reducing the use of agrochemicals and of agricultural machines, improving the environmental quality. The use of agrochemicals is the main form of intoxication of rural workers. Besides improving the rural work environment, transgenic agriculture could favor the reduction of contamination of foods, water and soils.

And modern biotechnology is the best response to these pressures, maintain the enthusiasts of transgenic food. Among the promises of GMOs are: the decrease of production costs, with increase in agricultural production and productivity; the creation of plants resistant to plagues, thus reducing the use of pesticides - with this, the possibility of intoxicating producers as well as environmental impacts decrease; nutritional gain of the food, since it is possible to produce transgenic varieties with greater nutrient concentration; efficacious contribution to put an end to world hunger; insertion of small farmers and regions in the current market; cooperation in the production of biofuels; relief in climactic changes and reduction of pollutants emissions (MARTINS, 2010).

As for the critics of GMOs, these could cause change in the metabolism of the plant or animal, causing the appearance of new toxins or allergens, besides changing the nutritional composition of the foods, reducing the available quantities of essential nutrients or elevating the quantity of elements that could harm human health, among others (PESSANHA and WILKINSON, 2003). Among the unexpected effects of the transgenics, there would be: change of interactions with microorganisms of the soil; susceptibility to pathogens; modification in the resistance to insects; change of the reproductive characteristics of the plants; less productivity of the transgenic soybean; variation in the levels of expression of the transgenic protein along the culture cycle. Still according to the critics, once decided for the release of the transgenics, its dissemination would be irreversible, since the new gene introduced in the seed could propagate without control in the nature (MARTINS, 2010).

In face of the promises of greater productivity as of GMOs, in 2007 Brazil was the country that had the greatest increase rate in the planting of transgenic seeds in the world. Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA) believes in the transgenesis while an alternative instrument of support to the Brazilian agriculture, “recognizing that obtaining transgenics is just a method of vegetable improvement when the possibilities of conventional improvement are exhausted, in which precaution is always put to evidence” (VALOIS, 2001 apud MARTINS, 2010).

2.5 USE OF GMOs

Despite the amount of information available on genetically modified plants (GMPs), the innocuousness of transgenics crops in relation to the environment and food safety is still questioned. According to Brookes and Barfoot (2005 apud CREMONEZI, 2010) some researches estimate the economic benefits and the cumulative reduction of pesticides, while others point out the growing

negative impacts, like the observation of plants resistant to applications of glyphosate herbicide, of toxic effect in the microfauna of the soil and the destruction of fragile environments, besides the consequent social and economic impacts.

Data reveal that commercial crops of GMOs are increasing by the year. In 1999 around forty million hectares were cultivated with transgenic vegetables, worldwide. The world market of transgenic plants, estimated in 75 million dollars in 1995, reached around two billion dollars in 1999, and approximately twenty-five billion dollars in 2010 (FINUCCI, 2010).

The most tested cultures were corn, tomato, soybean, canola, potato and cotton, and the most important genetic characteristics introduced were the tolerance to herbicides, and insects, the quality of the product and the resistance to virus. More than 11,000 assays were performed in fields between 1987 and 2000, scattered throughout 45 countries, with more than 81 crops of different GMOs, according to Borém and Santos (2001).

James (2004 apud FINUCCI, 2010) states that in 1996 the United States the large scale use of GMOs for commercial purposes started, with the introduction of Roundup Ready (RR) soybean. The planted area between 1996 and 2003 went from 2.8 million to 67.7 million hectares. In 2003 the GMOs were present in 18 countries, of which ten had around three billion inhabitants and Gross National Product (GNP) of US$ 13 trillion, almost half of the US$ 30 trillion world GNP.

The main producing countries were USA, China, India, Indonesia, Brazil, Mexico, Argentina and South Africa; such is the importance of the transgenics in large economies. Despite the resistance to GMOs by the European Union, the world growth of the transgenics did not stop (JAMES 2004 apud FINUCCI, 2010).

The world area of genetically modified plants is estimated in more than 80 million hectares, with special highlight to the soybean resistant to glyphosate herbicide (RR soybean), which is the most explored transgenic culture worldwide, with approximately 61% of the area (ROESSING; LAZZAROTTO, 2004 apud FINUCCI, 2010).

The consumer should be informed of the results through the labels of products which contain ingredients derived from GMOs, about the possible benefits or malefactions they could cause to human health and, in relation to the productive systems, a broad clarification about the possible harms to our biodiversity, by means of a divulging work by public and private organizations connected to this sector (TERSI, 2011).

3 FINAL CONSIDERATIONS

Several researches and studies demonstrate that biotechnology is responsible for improvements in humanity's quality of life and that its study brings benefits to the production of foods and in the development of new health technologies. It is, however, observed that a better detailing of its effects in human health is necessary, by means of more detailed researches and studies performed by universities and research organizations, aiming at the transparency of information as to the benefits that its use could have in agriculture, its effects in the environment and for the population. The studies should also indicate the possible harms that this technology

could cause to the environment, to the productive systems and to the human being through the consumption of genetically modified products.

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