

# Transgenic and Organic Food – A Brief Review of the Literature about Concepts and Consumer Perception in Brazil

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## **Abstract**

Genetically modified food (GMF) and organic food (OF) are two different forms of food production that are becoming more popular and drawing more interest worldwide in recent decades. The aim of the present article was to provide a brief review of the literature about concepts and consumer's perception aspects in Brazil related to GMF and OF. Scientific database such as PubMed, Scielo and ScienceDirect were consulted and a total of 33 references were identified as informative and relevant for this study. While large industrial groups sponsor the production of transgenic, the production of organic food is counterpoint, valuing the local issues and the preservation of the environment. However, far from being complete opposites, these two forms of production have strengths and gaps still to be filled to the full understanding of what they are and what they can offer to the consumer. So far, there is incongruous information about effects and/or benefits from consuming GMF and OF and, in response, it is observed a wide lack of knowledge from consumers.

**Keywords:** Transgenic Food, Organic Food, health, environment, consumer.

## **Introduction**

The production of safe and quality food is a major challenge for modernity. The growing number of consumers, the depletion of natural resources, increasing competitiveness among

nations, changes in the population lifestyle, problems related to food shortages and hunger are great demands nowadays.

In this context, a discussion that is placed is to compare different ways to obtain food, what are its potential benefits and risks and how the consumer stands in relation to these different forms. Genetically modified food (GMF) and organic food (OF) are two possibilities in relation to conventional cultivation of food that have been gaining strength in recent decades. On a more superficial analysis, one can say that these two forms of production are in many different directions but further analysis is needed for correct understanding of these two forms of production.

The use of genetically modified organisms (GMO) for the production of food appears with the potential of producing healthier food; resistant crops to adverse weather, lower production cost and higher productivity, on the other hand, the risk of genetic alterations on health of individuals and on environmental relations have not been well elucidated.

As for organic foods, they advertise an environmentally responsible manufacturing and food production without pesticides and potentially more nutritious, on the other hand, low production and distribution structure and higher cost to the consumer are the main obstacles.

In the center of all these discussions there is the consumer, who often does not have sufficient evidence to choose with certainty the best option of food to place on the table and to ensure health and well-being. The discussion of concepts related to these different forms of food production and the perception of them is essential to give more guarantees to consumers.

The aim of this brief review was to analyze the consumers' perception in Brazil related to GM and organic foods, in addition, presenting some important concepts related to these two types of food based on what has been published about these subjects.

## **Methodology**

Scientific database such as: PubMed, Scielo, and ScienceDirect were consulted from June to November of 2014 using the conjunction of keywords "genetically modified food", "transgenic food", "organic food" "benefits", "effects", "consumption" and "consumers". The articles related to the consumer's perception were restrictedly selected as the ones conducted with Brazilian consumers. In total, for the preparation of this review, 33 studies were selected and analyzed in relation to concepts and in relation to the consumer's perception.

## **Results**

### **Transgenic Food (GM Food)**

#### **Techniques of production**

The World Health Organization (WHO) defines genetically modified organisms (GMO) such as those organisms in which the genetic material has been altered in a way that does not occur naturally (Domingo, 2007).

GMF or transgenic foods are those produced through genetic and biotechnological changes. In recent decades, there have been significant advances in the use of these tools, which led to an increase in the number of GMF in the world market. GMF may have different characteristics compared to conventional, such as foods with higher nutritional value; sweeter or pitted fruit, longer lasting foods, etc. There are also changes to food producers, with the development of more resistant plants to pests and the force of nature (rain or prolonged drought, for example), which leads to an increased agricultural productivity (Menasche, 2003).

Production of GMF occurs through various techniques such as recombinant DNA technology, infection by *Agrobacterium tumefaciens*, bombardment and protoplast electroporation.

Recombinant DNA technology cuts DNA fragments at specific points using cleavage enzymes. After cleavage, selective isolation of a segment of interest (cloning) also occurs, by joining this segment to other DNA that serves as a carrier or vector, and finally introducing the modified DNA molecule into other organism. Thus, it is possible to introduce characteristics of interest via insertion of one or more genes into the plant genome (Vieira & Vieira Júnior, 2006).

The second technique is to plant infection using the bacterium *Agrobacterium tumefaciens*, which has intrinsic ability to transfer genes from its cell to plant cells. In this technique, changes are made to the DNA of the bacterium by insertion of the gene of interest. Then, the modified bacterium is placed in contact with the plant so that there is a transfer of genes from one species to other. This technique has been applied to the production genetically modified of tobacco, tomato and canola. (Guerrante, 2003).

Other technique is bombardment, also known as biobalistic, which uses micro projectiles that accelerate the rate of introduction of DNA into cells *in vivo*. The accelerated micro particles pass through the cell wall and the plasma membrane in a non-lethal way. Then the DNA is dissociated from the micro particles by the action of the cytoplasm and the process of integrating of foreign genes occurs into the genome of the organism to be modified. This technique is applied to produce genetically modified crops of soybeans, corn and wheat (Guerrante, 2003). Other possibility is the protoplast electroporation using a high voltage electric field for a short period of time. Cells modified by this technique are plant cells or fungi called protoplasts. They do not have the cell wall to facilitate the entry of DNA of interest (Guerrante, 2003).

The production of GMF varies in type of technology used and type of food produced. In the USA, the most produced GMF are corn, cotton and potatoes. They have longer shelf life and the culture is resistant to insects. The change produced is called 'bt'. Upon insertion of genetic material from one type of bacteria found in soil (*Bacillus thuringiensis*) these foods start to produce proteins that are able to protect the plant from insect attacks. These proteins act destroying the intestinal follicle of the insects, causing insect death. This is the general mechanism of action, but there are variations, depending on the inserted gene. An example of corn with a 'bt' alteration is called "StarLink" in which a gene called Cry9 (c) is inserted, which generates a protein that is toxic to corn borer and other insects (Leite, 2000; Guerrante, 2003).

Other example of GMF is FlavrSavr tomato, which was approved for consumption in the USA in 1994. It features a differential more vigorous maturity. This feature is due to the introduction of a DNA sequence encoding polygalacturonase, an enzyme responsible for hydrolysis of cell wall components of tomato, which operates during ripening (Guerrante, 2003).

### **Transgenic foods in Brazil**

In Brazil, the cultivation of GMO plants began in the late 1990s. The transgenic soybean was planted illegally in Brazil; mainly in Rio Grande do Sul, through smuggling from Argentina, where this type of soybean was cultivated in large scale. In 2005, an interim measure allowed the cultivation of transgenic soybeans in the Brazilian regions in which it had been imported illegally since the late 1990s. In the same year it was enacted The New Biosafety Law, n°11,105 of March 24, 2005, which definitely regularized the planting of GM foods in Brazil (Ribeiro& Marin, 2012). At that time, according to Allain et al. (2009), the Brazilian press demonstrated major interest in introducing the transgenics based only on the economic aspects and not in educating the population.

In terms of protection of plant species, Brazil adopted the *sui generis* protection system (European model) instead of patents (USA model). In 1999 Brazil joined the UPOV Convention

(International Union for the Protection of New Varieties of Plants) which opts for the unique system that takes into account criteria of protection of plant species such as: novelty, distinctness, uniformity, stability and prohibits the establishment of patents. The patent system, unlike the one adopted in Brazil, considers innovation, invention, and not just mere discoveries. The model chosen by Brazil is the best option for agricultural biotechnology from the point of view of researchers, farmers and consumers. However, although there is no patent system in Brazil, what is observed in the practice is that a small group of companies owns the market of both transgenic seeds and pesticides. Monsanto has almost a monopoly of the Brazilian market in this area (Leite & Munhoz, 2013).

The role of Monsanto has always been controversial regarding the legalization of GMOs in Brazil. The company's relationship with regulators certainly goes beyond the technological regulatory affairs. Not coincidentally, company representatives have eventually taken prominent positions in the committees responsible for the commercial release of GM crops, influencing decision-making due to their high degree of knowledge and by spreading a positive outlook on the quality and benefits of GMOs, even with lack of research that might prove otherwise. In addition, Monsanto also serves on the scientific environment, with financial incentives for research in genetic engineering branch in order to subsequently use opinions of these scientific groups to give credibility to their products and facilitate the argument for the commercial release of the company's technology. In Brazil, however, despite the action of the company to release the transgenic soybean there was a reaction from various sectors of society leading to a negative image of both the company and the transgenic soybean (Schioschet & Paula, 2008).

Regarding labeling, the Brazilian legislation imposes the obligation of identifying GMF or foods formulated from GM raw materials. According to the Brazilian Consumer Protection Code, consumers have the right to know what the characteristics are found in the product and its composition. Companies that produce GM food are against mandatory labeling in this type of food claiming that the statement could create some kind of prejudice against these foods by consumers, which would be detrimental to businesses (Câmara et al., 2008).

GMF when used well can benefit for the population, as in the case of genetically modified foods to control the ripening fruits, foods with increased nutritional value, such as oils with a lower content of fatty acids, etc. The mere ingestion of additional fragments of DNA/RNA itself is not dangerous, since these fragments are usually ingested through the diet. However, the changes produced in GM can lead to the formation of different proteins in foods, which can present toxicity, allergenicity or antinutritional characteristics. There is also the possibility of formation of undesirable substances (Lajollo & Nutti, 2003).

There is a possibility of increase in the resistance to antibiotics after insertion of new gene in the product. In the development of GM food, marker genes of bacteria resistant to antibiotics are inserted to see if the desired change is according to the plan. The insertion of these genes can increase resistance to antibiotics in humans consuming such products. For this reason, WHO and FAO do not recommend the use of these foods (IDEC, 2014).

### **Consumers' perceptions of GM food in Brazil**

Whether positive or negative, there is still a major lack of further studies on GMOs. The impacts that it can cause in human health and acceptance of the consumers about GMF are the most important aspect to be discussed.

A study on the degree of knowledge of GMF held in Paraná (Brazil) with the last year of high school students revealed some interesting information. Students were divided into two groups

(students from private and public schools). About 97% of students said they know GMF and about 95% expressed support for research with this type of food. However, the perception of action of this food was distinct in both groups. For students in private schools, 73% said that such food would not compromise the health and 78% that do not affect the environment. While in the group of public school students the perception was reversed, with 62% stating that GMF may compromise the health and 65% that can compromise the environment. This result is interesting because it shows that the type of training received by students may strongly influence the perception in the GMF acceptance (Canossa et al., 2006).

In other study, 60 consumers in a supermarket of a noble district of Fortaleza (Ceará/Brazil) answered similar questions. In the evaluated group (of which 50% had higher education) it was found that 63% claimed to know what GMF was, 53% checked the label to check the indication of GMF, and of these 77% have never seen GM mention in labels evaluated. About a third of respondents said they believed only that GM would present risks to health, but 73% said they were in favor of the release of GMOs by the government after more research. Half of consumers said no mind consuming GMOs, but most of them had no knowledge of the application of GMF in processed food (Calvasina et al., 2004).

A third study evaluated the intention to purchase GMF food. A sample of 390 college students were interviewed and it was found that 50% favored the use of GMOs, but only 34% of them were informed about it. Regarding the intention to purchase, more than 50% expressed a preference for non-GM fruit, even if they present a higher cost (Siqueira et al., 2010).

Recent studies show that even with almost ten years of planting release transgenic crops in Brazil that the degree of informing in general public on the subject remains low. The study carried out by Souza (2013) with 400 respondents in the Federal District (Brazil) identified a high degree of ignorance in the population about GMF, especially among consumers of lower income and education, 46% of respondents had never heard of GMF and 76% had read little or no information about this type of food. In other study, Farias et al. (2014) also assessed the level of knowledge about transgenic among university students in Rio de Janeiro (Brazil), the authors classified the knowledge of this group as incipient. In this analyzed group, 69% said they did not know about possible benefits from the GMF and the same percentage ignores the possible impact of these foods on human health.

## **Organic Food in Brazil**

### **Definition and production of organic food (OF)**

The theme of healthy eating has gained importance in the daily lives of consumers, who increasingly are looking for foods free from harmful substances to health, such as pesticides. This trend has stimulated the market of organic food (OF). The production of this type of food began in the 1920s, however, the organic system in technological bases only started on a small scale in the late 1970s and gained ground in world agriculture from the 1980s. Nowadays, in Brazil, organic farming provides direct consumer products, especially dairy, chatting and fresh horticultural, with production concentrated in the states of São Paulo, Minas Gerais, Espírito Santo, Paraná and Rio Grande do Sul (dos Santos et al., 2013). The Brazilian government has even created the *Programa Nacional de Alimentação Escolar* (PNAE, National School Food Program) which determines that at least 30% of its resources should be, preferably, use for buying OF (de Andrade Silveiro & de Sousa, 2014).

According to the MAPA (Brazilian Ministry of Agriculture, Livestock and Supply) for a food to be classified as organic it must be free of substances that may endanger human health and also the environment. The use of synthetic fertilizers, genetically modified seeds or any type of

pesticide is not allowed. According to the MAPA's Normative Instruction n° 07/99 (Brazil, 1999), an organic farming shall be defined as:

“[...] Agricultural system which adopts specific techniques by optimizing the use of natural and socioeconomic resources available and respects cultural integrity of rural communities, with the objective of economic and ecological sustainability, the maximization of social benefits, minimization of non-renewable energy dependence using wherever possible cultural, biological and mechanical methods, in contrast to the use of synthetic materials, eliminating the use of genetically modified organisms and ionizing radiation at any stage of the production process, processing, storage, distribution and marketing, and the protection of the environment [...]”

More recently, organic farming was defined as a set of management practices that can help to keep people in the countryside, as well as to reduce the use of pesticides, meaning, it is an ecologically sustainable and economically viable activity at all scales of production (dos Santos et al., 2013).

Organic food market is growing throughout the world, including Brazil. In 2013 this market increased above 20% compared to the previous year. Currently there are over 7,000 producers of OF in the country and the potential of growth in this market is high (Ipd Orgânicos, 2014).

In Brazil, organic food has identification symbol in the labels and the producer must be registered to receive a certification seal. Borguini & Torres (2006) estimated that 90% of OF produces in the country are provided from small producers linked to associations and social movement groups while only 10% are linked to large producers of private enterprises.

Despite potential benefits of OF consuming, as the absence of harmful substances to health, there are still problems related to scale of production and hence the selling price. About 70% of the national organic production is done by family farms, which hinders the expansion of production scale. Thus, the price of organic food is in average 40% higher than the conventional product. Nevertheless, there is a class of consumers willing to pay more for these foods. These consumers believe that to purchase healthier food is an investment in health.

Much information has been reported about quality and benefits of OF, but there is still no consensus and more studies are needed. Sousa et al. (2012) performed a comprehensive literature review on different databases, with studies since 1990. These authors found that there is controversy on various aspects related to OF such as: impact on human health, the existence of chemical contaminants, quality of organic food compared to conventional and about the price of organic food. The authors indicated emphasis on low toxicity, shelf of life and increased content of some nutrients; however more comparative studies are needed to confirm the superiority of the nutritional value and health promotion. They also cited that OF production means should be better discussed within broader social context.

Same examples of controversy about OF can be cited in two relatively recent studies. In the study conducted by Nascimento, Silva & Oliveira (2012) a comparison was made of iron and copper concentrations between organic and conventional vegetables sold in Maranhão (Brazil). The two minerals were analyzed in samples of lettuce, cabbage, watercress and okra. Firstly, the iron content was found suitable in all evaluated vegetables; however, there was an excessive amount of copper in the samples of kale and watercress from organic farming. In other study, Arbos et al. (2010) evaluated the antioxidant activity and total phenolic content in samples of organic and conventional lettuce, arugula and watercress planted in the same garden. The results indicated a higher antioxidant activity in organic compared to conventional crop. The

comparison of these two studies, as an illustration, shows that different results may be obtained on organic and conventional farming food, so further investigation and broader approaches are needed to confirm the potential benefits related to organic cultivation of food ensuring their safety and quality for human consumption.

Despite the controversies, the cultivation of OF acquires a particular importance regarding to family farming. In a context linked to sustainability increasingly present on the global stage, organic production may represent an alternative for family agriculture in relation to social, environmental and economic aspects, adding value to this type of production (Neto et al., 2010). Portilho & Castañeda (2008) highlighted another important aspect about OF in recent years that is a challenge for this market - building trust between consumers and organic products. This relationship has been widely changed, since more and more OF is no longer only sold in organic fairs (in which there is direct contact between producer and consumer) and are becoming more common in supermarket chains, in which guarantee origin given not only by the producer-consumer confidence, but also certification systems.

### **The relationship of consumers with OF**

A behavioral study conducted among consumers of organic food in the city of Belo Horizonte draws an interesting profile of consumer of OF. Through the theory of means-end chain, the authors found that consumers of these foods have an ego-trip type behavior, that is, they value autonomy, pleasure, wellness, healthy living and closer relationship with nature. Values such as longevity, quality of life, tranquility and happiness (terminal values), and inner harmony with nature, responsible consumption, live well life, caring for the health and economy of time and money (instrumental values) are striking characteristics of this group. However, there was more desire for individual values than the collective in the evaluated group. (Boas, de Souza & Brito, 2011).

Other study evaluated the profile of consumers of OF in the countryside of Paraná (Brazil) and it was found that 27% of respondents do not know OF; 11% know, but do not consume; and 8% consume, but do not want to pay more for OF. According to the same study, 39% of people consume OF for selfish reasons, while only 15% for more altruistic reasons. The study also found a lack of knowledge about OF especially among housewives, young and low-income consumers (Constanty et al., 2013).

Andrade and Bertoldi (2012) evaluated the consumer market for OF in Belo Horizonte (Minas Gerais/Brazil), both socioeconomic and behavioral points of view of consumers in a sample of 400 people. Most respondents were female (76%), aged over 30 years old (90.3%), in a stable relationship (81.3%) and graduate (81.5%). In this group, 69.7% defined OF as pesticide residue free products; 82% considered that OF is nutritionally richer than conventional; 75% believe that these foods are GMO free and 86% believe that OF is synthetic free. Regarding behavior, the majority seeks to maintain healthy lifestyles and 98.8% cited improvements in health after incorporation of OF in the diet. However, only 16.3% consumed other OF different of vegetables and fruits. The authors indicate that the majority of respondents had only superficial knowledge of the subject; they also detected a strong demand and interest in OF. The high price and low quality were the main factors that limit the consumption of these products.

Barbosa et al. (2011) included the problem of OF prices in their study. It was found that among consumers from Goiânia (Goiás/Brazil) the main difficulties in relation to OF consumption were related to the high price and low availability. It was found that organic products like pumpkin, eggplant, sugar beet, carrot, and cucumber presented more price changes over the conventional ones.

Despite the examples cited above, it is interesting to note that even with a growing interest in OF in Brazil, the number of studies exploring this theme is still relatively small. An interesting study published in 2013 made a survey of the literature in organic products in Brazil. It evaluated papers published in journals (with rating from A1 to B2 in the Qualis System) and in Brazilian scientific events of the business administration area from January 1997 to March 2011 and they found 54 articles published in journals and 63 in scientific events. In this total, only 4 journal articles and 10 scientific events evaluated the consumer behavior. The main conclusions were that the majority of published studies are from the South and Southeast regions of Brazil, exploratory and preferably adopt the primary data collection and empirical studies. These figures also show the low level of exploration of this theme in Brazil (Sampaio et al., 2013).

## Conclusion

From this brief literature review, it is possible to draw some important conclusions about GM and organic foods. On the first group it is possible to note that there are different techniques to obtain GMF and many possibilities of use. However, so far from the commercial point of view, few varieties have been produced and in general these varieties presented different characteristics in relation to aspects of culture (such as increased resistance to pests), the nutrition or consumer health aspects. There are still relatively a small number of studies with consistent data on the impact of GMF on human health and the environment. There is also a high degree of lack of knowledge in the population about what it is and what are the implications of the consumption of GMF. The second group arouses interest due to the lower risk of contamination by pesticides and higher nutritional potential. However, some issues need to be further explored such as: degree of knowledge of consumers, the high price and small-scale production. It is possible to note that consumers have unclear concepts about OF. The studies found in the literature are also inconclusive on the two main attractions of these foods - no residues of pesticides and greater amount of nutrients. Moreover, the price is one of the biggest barriers to OF, both for access by the consumer as well as to the development of larger scale production.

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