HOW THE NEW TECHNOLOGIES IN FOOD PRODUCTION AFFECT CONSUMER CHOICE?

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ABSTRACT
Over the years, improved techniques for production and processing of food have resulted in the expansion of our food supply by prolonging keeping times, preventing spoilage and increasing the variety of food products available. The use of new technologies in food production has potential benefits for both food manufactures and consumers. But one of the question raising is how consumers react to the new technologies and how does it impact their choice to buy or not to buy such kind of food. This article examines how the new technologies in food production (genetic engineering, nanotechnologies, cloning) affect consumer choice to purchase food obtained through these technologies. Different literature and scientific data available were summarized to find out the main reasons what affect consumers' attitude towards new technologies in food production. Results suggest that the willingness to consume food obtained with help of new technologies is directly influenced by the risk consumers perceive and the perception of risk is more direct than the perception of supposed benefits.
KEY WORDS: *consumer attitude, cloning, GMO, nanotechnology, new technologies.*

JEL CODES: M38; I18; L66; O13.

Introduction

The current global population is exceeded 7 billion with 50 % living in Asia. A large proportion of those living in developing countries face daily food shortages as a result of environmental impacts or political instability, while in the developed world there is a food surplus. For developing countries the drive is to develop drought and pest resistant crops, which also maximize yield. In developed countries, the food industry is driven by consumer demand which is currently for fresher and healthier foodstuffs (Joseph and Morrison, 2006).

It's a why question of use of new technologies in food production is a hot debate in many countries all around the world. Many supporters of new technologies point to potential to improve quality of human life and environment. While new technologies refer to a number of economic benefits not just for food production but also for other industries, the community holds a lively discussion referring to health concerns, social, economic aspects and political preferences.

The use of new technologies in food production has potential benefits for both food manufactures and consumers. But at the time when the food industry is creating the new products and new ingredients, the farmers are growing the new crops with improved or modified characteristics, the question is open whether the new technologies and industries invested money are cost effective, are the new products accepted and assumed by the consumers.

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This article examines how the use of genetic engineering, nanotechnologies and cloning affect consumer choice to purchase food obtained through these technologies.

In this study it is summarized available scientific data on consumer attitudes towards new technologies in food production (genetic engineering, nanotechnologies, cloning) and identified the key indicators that make up the consumer point of view and attitude. Many kind of different literature and scientific data were analyzed to compare attitude of consumers from different countries of the world towards use of new technologies in food production.

1. Gene engineering

One of the hottest topics of discussion in our days is gene engineering. We can consider that history of genetically modified organisms (GMO) started in 1973 when the first GMO was obtained – an E.coli bacterium. Since that time many food plants and crops are being genetically modified, introducing a new trait to the plant which does not occur naturally in this species. Examples include resistance to certain pests, diseases or environmental conditions; these are so called first generation of GMOs.

Second generation of GMOs is altered in such a way to increase nutritional value, quality of crops and also to reduce risk to human health. Methods to control gene expression are used, so the crops produce higher concentrations of known nutrients and disease-fighting compounds. An example of a crop with altered gene expression to improve the quality of the product is the soybean that has been developed to produce more stearic acid, thus giving soybean oil better heat stability, to match the properties of trans-hydrogenated fatty acids. With this alteration, less hydrogenated oils can be utilized for the same traditional purposes as hydrogenated oils. One more example is tomatoes bred to produce higher amounts of lycopene, a compound that has been linked to lower blood cholesterol levels, and lower risk of breast and prostate cancers.

Actually obtaining of such plants is nothing new. Already more than30 years ago oilseed rape with very low toxic erucic acid content was obtained using selection methods. Today the rape is the main raw material in the world for the production of vegetable oil.

Research in the field of agricultural biotechnology has succeeded also in the development of many pathogen-resistant crops, able to fight disease and produce increase yields and/or improved quality.

Although there is intensive work ongoing to obtain genetically modified (GM) food with enhanced nutritional properties just few of them has reached the market.

2. Nanotechnology

Nanotechnology – engineering very small particles, usually defined at a scale of between 1 and 100 nm which now is widely spread in the food production. The application of nanotechnology to the agricultural and food industries was first addressed by a United States Department of Agriculture roadmap published in September 2003 (Nanoscale science and engineering for agriculture and food systems, 2003). The prediction is that nanotechnology will transform the entire food industry, changing the way food is produced, processed, packaged, transported, and consumed.

Nanotechnology has the potential to revolutionize the agricultural and food industry with new tools for the molecular treatment of diseases, rapid disease detection, enhancing the ability of plants to absorb nutrients etc. Smart sensors and smart delivery systems will help the agricultural industry combat viruses and other crop pathogens. In the near future nanostructured catalysts will be available which will increase the efficiency of pesticides and herbicides, allowing lower doses to be used. Nanotechnology will also protect the environment indirectly through the use of alternative (renewable) energy supplies, and filters or catalysts to reduce pollution and clean-up existing pollutants.

The impact of nanotechnology in the food industry has become more apparent over the last few years. Nanotechnology foods and food packaging are already commercialized, though the number of products is still low. The types of application include: smart packaging, on demand preservatives, and interactive foods.

Building on the concept of "on-demand" food, the idea of interactive food is to allow consumers to modify food depending on their own nutritional needs or tastes. The concept is that thousands of nanocapsules containing flavour or colour enhancers or added nutritional elements (such as vitamins), would remain dormant in the food and only be released when triggered by the consumer (Dunn, 2004).

3. Cloning

Cloning was originally used in microbiology and agriculture, and is the process of multiplying single organisms by means of asexual reproduction to create a population of identical individuals (EGE, 2008). Since 1996, when the first fully cloned domesticated farm animal, Dolly the Sheep, was born cows, goats, poultry and fish-based clones have been created, primarily through application of Somatic Cell Nuclear Transfer (which does not involve genetic modification) and transgenic cloning, which allows the breeding of hybrid animals using genetic material from different species. The scientific and commercial factors driving animal cloning technology in agriculture relate to improving the quality, productivity and environmental impact of breeding stock (Butler, 2009).

Issue of animal cloning for food supply is a new and complex topic, society and politicians is considering it carefully in the context of the existing legal framework, bearing in mind food safety, the desire of consumers for information, animal health and welfare, and other relevant factors such as ethical considerations.

It is obviously that over the past hundred years, the food assortment has dramatically changed, and with it has also changed the composition of the nutrient intake. Increasing people's interest in healthier food, there is an increasing interest in the nutrients that not only provides the body with necessary substances, but also improves the health and well-being.

4. Results

In many countries, such as USA, China, Spain, the Philippines, Mexico, South Africa, Belgium, Germany, Greece and others have been many different studies to find out the public's views and attitudes towards use of new technologies in food production. Attitude of consumers was found out applying a variety of methods, which are widely used in marketing research: focus group discussions, population survey, etc.

In these studies, the results identified a number of the aspects that make up the attitudes of consumers towards products made with the new technologies.

An international team of researchers from Denmark, Brazil, Belgium and Norway have a study towards use of new technologies in beef production chains and how does it affect consumers' opinion of meat products (Barcellos et al., 2010). Consumers form Spain, France, Germany and Great Brittan were involved in this survey. Results suggested a relationship between acceptance of new beef products, technology familiarity and perceived risks related to its application. Excessive manipulation and fear of moving away from 'natural' beef were considered negative outcomes of technological innovations. Beef processing technologies were predominantly perceived as valuable options for convenience shoppers and less demanding consumers. Overall, respondents supported the development of 'non-invasive' technologies that were able to provide more healthiness and better eating quality.

Most of the investigations are conducted in the field of biotechnology and use of GMOs in food production. For example, the field experiments were conducted in the German and French speaking part of Switzerland to compare revealed consumer preferences towards GM food (Aerni et al., 2011). In the experiment three clearly labeled types of corn bread were offered at five different market stands across the French and German-speaking part of Switzerland: one made with organic, one made with conventional, and one made with GM corn. In 2005, Switzerland expressed its negative attitude towards GMO use in agriculture and imposed a moratorium on GM crops in the country. However, five years later the results of mentioned experiment showed that Swiss consumers treat GM foods just like any other type of novel food. It was con-

cluded from findings that consumers tend to appreciate transparency and freedom of choice even if one of the offered product types is labeled as containing a genetically modified ingredient.

According to investigation of Washington State University (Heffernan and Hillers, 2002) taking into account that GMO product labeling is not mandatory in United Sates (US), most of consumers even were not aware of consumption of GM products. Respondents were most likely to agree that citizens have too little information in whether biotechnology is used in the food. 20 % of the respondents (mostly women) agreed with the statement that biotechnologies should be banned because of potential risks to the environment. When the question focused on reduction of pesticide use, half of the respondents supported (although 18% were against) the use of biotechnology in agriculture and the cultivation of GM crops. However, almost all of them also put attention to consider risks to non-target organisms such as Monarch butterflies which could be affected by such GM crops. The majority of respondents also believed that the U.S. legislation in this area is not too severe. Only 37 % of respondents in this study were aware of the widespread presence of GM products in the U.S. food supply.

In the position of American Dietetic Association (Agricultural and Food Biotechnology, 2006) it was argued that agricultural and food biotechnology can improve the quality and safety of food, increase its nutritional value and variety of food available for consumption, improve the productivity of food production, food processing, distribution, and environment and waste management. In addition, the Association urges the governments, food producers, distributors and retailers, as well as food experts and professionals to collaborate to ensure awareness of consumers about new technologies and their benefits.

The objective of consumer's survey which was conducted in 2009 in China in collaboration with Wageningen University, Netherlands, was to identify the underlying subgroups of Chinese consumers in terms of their perceptions and attitudes toward GM foods (Zhang et al., 2010). The results showed that the Chinese acceptance and willingness to buy GM food is much higher than in many other countries around the world. Several regression analyses carried out also indicated that income plays an important role in consumers' acceptance of GM food in China. People with low incomes more concerned about pesticide residues in vegetables and fruits. Their willingness to buy GM foods was quite high since they saw GM technology as the best current solution to prevent plant diseases and reduce pesticide use. Consumers more interested in nutritional benefits had the higher probability of buying GM foods as they saw the direct nutritional benefits that GM technology can bring to consumers. The consumers with high income, were less concerned about food, but were more concerned and showed greater interest in non-food application of GM technology, such as in medicines.

The study revealed that 14 % of respondents saw the benefits of the development of second generation of GMOs, which can help to improve food quality, nutritional value, taste, etc. Approximately 26 % of the Chinese did not support the use of GMOs in food production at all.

Although China already has a comprehensive agricultural GM biosafety regulatory and monitoring system, the biosafety evaluation and approval procedure require more transparency to enable consumers to better understand biosafety issues and improve their trust in government's ability to regulate GM technology and to allow only GM technologies that are safe to human health and to the environment to be introduced.

According results of investigation conducted in 2009 by Miguel Hernandez University in Spain, concretely in the province of Alicante, located in the southeast of this country, the use of biotechnology is a sensitive issue among consumers due to potential risks to human and animal health and the environment. However, producers were noticing a direct economic benefit, so that in society an economic, as well as a political and social, debate is taking place concerning this topic (Martinez-Poveda et al., 2009). In spite of GMO labeling being recognized by the majority of consumers few really knew its meaning or implications. Possibly due to this lack of knowledge, there was growing interest among consumers on GMOs and a desire to acquire knowledge of this matter. Consumers stated that in most cases information is scarce and unclear. Besides, they demanded information from a credible source of health and scientific professionals. Consumers indicated that the available information is a daunting and confusing, and the need to look for other reliable sources of information to experts in the field.

One of the aspects that concerns Spanish consumers the most, was the perceived risk from the consumption of certain foods. The case of GM food should be very particularly considered since it deals with a product without previous experience on the food market.

Detected factors that influence perceived risk for GM foods were: existing information, the source and credibility of that information, and consumer concern for health.

Investigation of Swiss Federal Institute of Technology (Aerni and Bernauer, 2006) tried to find out stakeholder perceptions and interests in the public debates on the risks and benefits of GMOs in developing countries (Philippines, Mexico and South Africa). The study found out that most local stakeholders in these countries tend to have pragmatic views toward the use of GMOs. Yet, they also revealed a trend toward political polarization that is linked to the transatlantic dispute on GMOs.

The survey results showed that most of the stakeholders believed that agricultural biotechnology had the potential to solve important problems in agriculture (drought, pest infestation, plant disease, high use of pesticides), and did not pose a significant health risk to consumers. Yet, there were also concerns regarding the potential negative impact of such crops on the natural environment and the difficulties of implementing strict regulations well as lack of market access, too little investment in research and development, and infrastructure. The results of the surveys suggest that the differences in perception in the Philippines, Mexico, and South Africa were often related to different historical, political, ecological, and socio-economic conditions.

Aarhus school of Business in Denmark conducted a study on the use of enzymes in food production (Søndergaard et al., 2005) with aim to find out how consumers react to new ways of producing foods with enzymes. This study investigated the formation of consumer attitudes to different enzyme production methods in three European countries (Finland, Germany and Italy). Results showed that consumers were most positive towards non-GM enzyme production methods and non GMO use in general. Results also showed that environmental concern and attitudes to technological progress are the socio-political attitudes that have the highest predictive value regarding attitudes to enzyme production methods. Especially attitudes to technology, social trust and the level of knowledge of enzymes and biotechnology showed large variations between countries, indicating that the role these play for attitude formation may be culturally dependent. Attitudes to the enzyme production methods have a fairly strong impact on buying intentions for the product concepts tested, whereas price and the benefits have minor effects.

In cooperation with several scientific institutions in Germany there was the study performed to analyze the attitudes towards genetic modification, the knowledge about it and its acceptability in different application areas among German consumers (Christoph et al., 2008).

The results revealed that consumers' attitudes towards the use of GMOs in areas other than the food production are much more favorable than the use of GMOs in food production.

According to the results, it was doubted that future studies about risks and benefits will make consumers change their attitudes towards genetic modification. The consumers who opposed genetic modification lack trust in authorities, industry and scientists. Even if new studies showed the risks of GMOs are nonexistent or manageable, these consumers would be unlikely to change their attitudes because they would lack trust in the source of information.

It was also found out that education was not cause to support genetic modification, because good knowledge does not automatically imply support as this study showed.

As everywhere, people in Germany had different opinions about technologies and there was not a single one which was supported by all consumers. Genetic modification will likely never reach full support. Therefore, a successful management of the coexistence of GM and GM-free production appears to be a crucial step in fostering the social acceptance of the technology.

In view of the study conducted by the experts from different European scientific institutions (Frewer at al., 2011) citizens of Europe in general were mostly skeptic and pointed out particular concerns related to unpredictable effects, uncontrolled use, and ethical concerns of new food production technologies: genetic engineering, animal cloning, nanotechnologies etc., considering that the potential risks does not justify the use of these technologies in food production.

Trust in regulation and other important food chain actors, such as those associated with the food industry, was also important. If consumers can control consumption of associated products (with labeling for example) then it is anticipated that consumer acceptance is likely to be higher compared to situations where applications are uncontained and untraceable.

The impact of nanotechnology in the food industry has become more apparent over the last few years and there are also some data available regarding consumer's attitudes towards use of nano-food.

Key issues of the study performed in Ireland were to investigate consumers' awareness of and attitudes towards nanotechnology, the subjective values (including perceived risk-benefit trade-offs) that frame these attitudes and the influence of new information on consumers' attitudes and acceptance (Dillon, 2011). According data obtained consumers were more accepting of the different applications presented if they perceived the associated personal and societal benefits to outweigh potential risks. However, consumers were not homogenous in their perceptions of the applications. Product characteristics (e.g. perceived naturalness), subjective values, individual risk assessments, trust in stakeholders and personal control, general risk sensitivity and attitudes towards technology, familial relevance of such applications, and societal and environmental factors framed consumers' attitudes towards the nanotechnology applications presented.

An experiment was conducted in France and Germany to evaluate consumers' willingness to pay for food nanotechnology focusing on two applications: nano-fortification with vitamins and nano-packaging. Results show that many consumers in both countries are reluctant to accept nanotechnology in food - French consumers are more reluctant to accept nano-packaging, whereas German consumers are less inclined to accept nano-fortification compared with the respective other application.

For this moment direct empirical evidence on public perceptions of food products derived from cloned animals is limited. Not all consumers share the same attitudes toward animal cloning, but data available for this moment shows that Americans may be more accepting of consuming cloned animal products than Europeans.

A survey conducted in the US by the International Food Information Council in 2005 reflected that 34 % of respondents would be likely to buy food products from cloned animals if the Food and Drug Administration determined them to be safe to eat (compared to 64 % against). Accordingly, public perception of animal cloning is likely to play a major role in its development and its commercial prospects. This perception may vary greatly between countries, including between EU Member States (EGE, 2008).

For Europe much of the research stems from the series of *Eurobarometer* surveys on Biotechnology (1996, 1999, 2002 and 2005). According to *Eurobarometer* data (1999), it should be noted that the only animal application explicitly mentioning cloning (Cloning animals such as sheep to get milk which can be used to make medicines and vaccines) is the second least supported application – surpassed only by GM foods. This seems to indicate that cloning is a particularly controversial technology. However, the skepticism may reflect not only the above-mentioned *animal-factor*, but also the historical context of the late 1990s. Hence there is a clear resemblance between the application asked about and the, at that time, well known and in many countries alarming, arrival of Dolly the sheep. The low score may thus partly reflect generally negative discourse about Dolly in particular and cloning in general that prevailed in many EU countries in the late 1990s (Lassen, 2007).

In 2005, a *Eurobarometer* Survey on Social Values, Science and Technology conducted further study. In this survey, respondents from the 25 European member states were asked to indicate their approval of "growing meat from cell cultures so that we do not have to slaughter farm animals". This proposal was rejected by 54 % of the respondents (EFSA, 2007).

It is obviously that all these findings indicate that consumer attitude toward use of new technologies is very complex as it is impacted by different concerns and uncertainties.

Conclusions

This study has indicated a number of factors that may be associated with consumer responses towards new food technologies. Summarizing data available it is clear that food obtained with help of new technologies affects markets differently and the behavior of different social groups in its development is also different depending on whether they are producers or consumers. Producers seem better disposed toward the advances offered them by new technologies since they are the first to receive benefits from adopting them. Nevertheless, consumers are reluctant at present about the entire new technologies in food chain. Their willingness to consume such kind of food is influenced by the risk they perceive and the perception of risk is more direct than the perception of supposed benefits, and therefore, attaining a positive consumer attitude toward these foods is a job that will require a lot of time.

The public attitude towards the use of new technologies in food production varies drastically from geographical areas (such as the U.S. and China are more positive, while EU countries and Switzerland – rather negative), such aspects as traditions, history of consumption and ethical considerations impact majority of consumers all around the world.

Confidence in regulatory authorities and other important food chain operators, such as those associated with the food industry, is also important. Control, freedom of choice and traceability of associated products (with labeling for example) makes out that consumer acceptance is likely to be higher compared to situations where food are uncontained and untraceable. Although despite the fact that in many countries labeling of food obtained through new technologies is mandatory, the majority of the public do not realize and understand the meaning and purpose of this label. They perceive the label more as a warning of the danger than the information about food ingredients or method of production.

At the present time it seems that the public is not fully informed about the uses and implications of cloning. Taking into account the precedents of GM food, public interest would be likely to intensify as products came closer to marketing although it should be also mentioned that knowledge about public perceptions in this area also varies both geographically, since the number of studies differs from country to country, and historically, since the studies do not cover the development of opinions over lengthy periods of time.

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NAUJŲJŲ TECHNOLOGIJŲ MAISTO PRAMONĖJE POVEIKIS VARTOTOJŲ PASIRINKIMUI

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Santrauka

Tobulėjant maisto gamybos ir apdirbimo technologijoms pailgėjo produktų galiojimo laikas ir padidėjo prieinamų produktų įvairovė. Naujų technologijų taikymas maisto gamyboje naudingas tiek vartotojams, tiek gamintojams, tik kyla klausimas, kaip vartotojai reaguoja į naujų technologijų taikymą maisto gamyboje ir kaip tai veikia jų sprendimą pirkti tokius produktus ar jų nepirkti. Šiame straipsnyje nagrinėjama, kaip naujosios technologijos maisto pramonėje (genų inžinerija, nanotechnologijos, klonavimas) veikia vartotojų pasirinkimą pirkti maisto produktus, pagamintus šias technologijas taikant. Siekiant nustatyti pagrindines priežastis, kas lemia vartotojų nuostatas dėl naujų technologijų taikymo maisto pramonėje, apibendrinta mokslinė literatūra ir tyrimai šia tema. Tyrimo rezultatai leidžia teigti, kad noras vartoti produktus, sukurtus taikant naujas technologijas, tiesiogiai susijęs su vartotojų rizikos suvokimu, pastarasis yra labiau tiesioginis nei galimos naudos suvokimas.

PAGRINDINIAI ŽODŽIAI: *vartotojų nuostatos, klonavimas, GMO, nanotechnologijos, naujosios technologijos*.

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