Food safety. Commodity science point of view

Romuald I. Zalewski and Eulalia Skawińska
Poznań University of Economics, Poznań, Poland (romuald.zalewski@ae.poznan.pl)
Poznań University of Technology, Poznań, Poland (eulalia.skwinska@put.poznan.pl)

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Abstract

The paper addresses "food safety" and "food quality" from the position of commodity and food science rather than economy. The various descriptions of both terms in literature are reviewed in connection with customer/supplier ability to evaluate food safety and quality by examination of various characteristics. Food safety has been described as opposite to food risk. Differences in perception of food risk by customer, producer/supplier and official agencies are discussed in this paper. The objective safety (and quality) of food can be evaluated using three categories of food risk (biological, chemical and physical) measured on a seven step intensity scale by producers and official agencies but not by customers. This leads to formulating food safety policy which has been described as a set of voluntary, obligatory and supplementary systems under inspection of official bodies.

The efficiency of this formulation has been examined and described for Wielkopolska region of Poland. The results indicate sufficient analytical performance of laboratories in industry and some gaps in co-operation with official food safety control institutions.

JEL classification: Q13, Q18, M31

Keywords: food safety, food quality, risk

‘... availability of sufficient amount of safe food is the right of each person’ (FAO/WHO Rome 1992)

1. Introduction

Food safety and quality are now in the center of interest of commodity science, food industry, foodstuff suppliers, public opinion and today’s agricultural economists. Both safety

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1 This is in line with “the trend towards greater position of safety in other areas such as workplace safety and environmental protection” (Segerson, K.. Mandatory versus voluntary approaches to food safety, Agribusiness 15(1) 53-70, 1999).
and quality are in this case inseparable. The term “food safety” can be used in two meanings which result from different scientific roots. From the position of commodity science, food technology, science and quality, food safety means that probability of illness, poisoning or injury as a consequence of consuming a certain food is very small or negligible (Codex 2003). However, food safety can be understood from the position of economy as safety of production supply chain coordination, availability, continuity and sufficiency for consumer and industry. This is more intriguing for agriculture economists, politicians or public opinion interested in product liability, terms of international trade, interactions between risk analysis and economic analysis (Unneweh et.al. 2003). For example agri-food issues of EU accession negotiations with Eastern European countries, food regulations and trade towards an open global system, estimation of effects of agricultural policy on poverty in Europe and developing countries (Winters 2005) or the geography and causes of food insecurity in developing countries were also discussed in the literature. The issues connected with such a meaning of food safety will not be developed and discussed in detail in this article.

2. Food quality

The term “quality” has been defined in literature by various authors in different ways. The most comprehensive definition states that quality means “fulfilling the needs/requirements of a customer” (Juran 1974, Crosby 1995). According to the well known ISO 9000:2000 international standard “quality is a degree to which a set of inherent characteristics fulfills requirements. There is no doubt that quality is relative and does not exist on its own. Quality perception is not constant in time or location because consumers’ needs change. Suppliers and producers of food must describe the target through market segmentation. Such segmentation could be driven by examining consumer structure of quality attributes according
to their importance. Some attributes are very important (critical) in eyes of consumers and other less or even not important for a given person or segment of customers. Research conducted in Poland by means of survey analysis followed by Principal Component Analysis of experimental data (Kowrygo et.al. 1997) indicated the following order of attributes connected with quality: health, disposability and sensory parameters (freshness, appearance, taste, smell/odor and durability). A mature and experienced consumer is able to evaluate e.g. fat content in cheese, milk and sausages or sugar in soft drinks by tasting them. Other food attributes such as influence on health and well being, easiness of preparation, chemical constitution, presence or absence of various substances are no measurable and less important in the opinion of consumers. However, their role is growing due to better education, increasing awareness of food labeling which decreases the information asymmetry in food chain. Quality assessed in such a way is rather subjective. The assessment would be much more objective if carried out by person(s) specialized in sensory analysis (Jelinek 1985).

Paola Bertolini et.al. (2003) studied desirability ranking of 19 characteristics of food in three countries (USA, Italy and Japan) and found large differences. In general, quality and sensory characteristics are on the top. Other attributes such as high nutrition value, being free of pesticides, good for environment and safe for workmen, got a lower rank. However, Japanese consumers were more directed towards food safety characteristics e.g. irradiation, GMO free, genetically modified food. American and Italian consumers were more likely to trust their governments about food safety than Japanese consumers.

In the light of previous research, food quality is a composition of three basic attributes: healthiness (constitution), sensory perception and disposability which are shown in Figure 1. Each attribute is further divided into values for a consumer and then into particular food or product characteristics. Health attribute is shown as a construct of four values: energy value, nutrition, dietetics and safety, which is the most important for our further discussion. The
outcome of all these characteristics will yield perceived or expected quality of food under study.

Figure 1. Attributes and characteristics of food quality

On the other hand, objective food quality is a result of evaluation of measurable characteristics and properties of a given food. For measuring such properties various scientific (physical, chemical, microbiological etc) methods are used. Such methods are based on highest scientific achievements and are officially approved by various independent institutions e.g. Codex Alimentarius, FAO, WTO. The execution of measurement is in hands of food control laboratories in industry, supply chain, official control institutions or independent establishments, e.g. consumer organization, private laboratory. The accuracy, precision, repeatability, performance etc. of their work is examined by other laboratories at higher level. In the EU, a net of four Community or National Reference (CNR, NRL) Laboratories has been established to examine food residues and contaminations of animal origin (Caroli 2005). During the last decades, the evolution of quality significance has been observed and documented (Volberda 1999, Zalewski et.al., 2004). Impact of science on quality issues has shifted the attention from quality control of processes and products to prevention (Deming
1982) which leads to better understanding of processes. People have accepted that it is better to build-in desired product quality at the initial stage of its life-cycle. For example, Poulsen and colleagues (1996) proposed models of quality creation and applied them to food products.

3. Food safety

It is evident from the food quality model (Figure 1) that food safety is one among four values for a consumer linked to a basic attribute: health. For example, food with low or inadequate nutrition or dietetic value is not healthy while being simultaneously safe. For our health and good condition a certain energy value of food is required. If one eats too much, energy intake is higher than necessary and can lead to obesity. In literature, one can find various definitions of food safety. For example Ritson et.al. (1998) distinguished broad and narrow ones. “In the narrow sense, food safety can be defined as the opposite to food risk, i.e. as the probability of not contracting a disease as a consequence of consuming certain food” (Grunert 2005). A similar description of food safety as protection of food against chemical, biological and physical factors which can endanger human health has been used by Codex Alimentarius (2003) and adopted by HACCP principles (Hazard Analysis and Critical Control Point).

There are three categories of food risk evaluated on a seven step scale (table 1):

1. biological
   - microorganism (e.g. Clostridium botulinum, Salmonella, Listeria, Staphylococcus, Bacillus aureus, Escherichia coli),
   - mycotoxins (Penicillium, Aspergillus, Fusarium),

2. chemical
   - contaminants present in environment as residues of harmful substances (e.g. heavy metals, radio nuclides),
• additives allowed in food but exceeding certain concentration limit (e.g. nitrates III and V),
• residues of pesticides, herbicides and other supporting chemicals,
• traces of chemicals migrating from packaging,
• residues of drugs, antibiotics and other medicines,
• residues of detergents and disinfection agents,
• lubricants, hydraulic liquids,

3. physical

• external (glass, wood, stones, plaster, metals, plastics, hairs, buttons etc.)
• internal (hair, bones, fish bones, fruit stones, straw).

Intensity of risk occurrence is measured on a seven step scale (see table 1).

Food safety in broad sense “can be viewed as also encompassing nutritional qualities of food and more wide ranging concerns about the properties of unfamiliar foods such as many European consumers’ uneasiness about genetically modified food” (Huffman 2003, Grunert 2005). This definition is included in description of total food quality (point 2).

<table>
<thead>
<tr>
<th>Risk level</th>
<th>Description (examples)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Non sterile products for consumers of special care (children, old people, ill people)</td>
</tr>
<tr>
<td>5 and 4</td>
<td>Products which may contain sensitive contaminants of microbiological origin or mycotoxins</td>
</tr>
<tr>
<td>3</td>
<td>Production process does not guarantee microbiological sterilization, and separation of unwanted physical matter.</td>
</tr>
<tr>
<td>2</td>
<td>Possibility of repeated infection after sterilization and before packaging</td>
</tr>
<tr>
<td>1</td>
<td>Unsuitable treatment of product in the distribution chain and home use</td>
</tr>
<tr>
<td>0</td>
<td>Products not heated before eating</td>
</tr>
</tbody>
</table>

Food consumers, producers, experts or scientists evaluate the food risk based on very different tools and knowledge. Producers, experts and scientists examine food safety using special procedures, methods, standards etc. The tools used must be of highest scientific values.

From consumers’ point of view, food safety and risk are evaluated as a subjective category, existing in their mind. Ian Shaw (2005), in contrast to many authors, sets the risk of food in the broader context of a life’s risk. Enjoyment of food is a benefit that far outweighs the risks, at least if everybody is aware of these risks and takes measures to minimize them. In general, food safety does not occupy high position in the ranking of food quality attributes. “This may suggest that perception of food safety affects a consumer’s food choice in a way that is different from perception of the other dimension of quality” (Grunert 2005) or that a consumer trusts food producers and suppliers (Bertolini et.al., 2003). However, consumers are very cautious of major safety problems namely food scares (like BSE, dioxins, nitrofen, bird flu, acrylamide, sudan 1) and certain processes or technologies (e.g. food irradiation, genetically modified organisms), sustainability affairs (Evanson et.al., 2003). In particular, consumer attitudes to GMO in food production were studied and indicated, for example, higher acceptability in USA and fear in the EU (Hauf et.al., 2002, Venturini 2003).

Three categories of consumer risk perception were founded by Grunert (2005):

1) technology-based risk is less acceptable than self – imposed one,

2) our risk of being hit by the problem is lower than average,

3) familiar risk is less severe than unfamiliar.

Food safety is an important topic for public debate for many reasons. The interest is driven by world-wide food scandals, possibilities of transfer of diseases through migration of people or
animals (bird flu) and expanding trade. Public policy is visualized through regulatory activity in a form of international standards for food safety and quality (e.g. GHP, HACCP, Sanitary and Phytosanitary Standards, Tracking and Tracing, ISO 9001, retailer standards etc). Another idea is to decrease an information gap between a consumer and a producer, introduce strict rules of food labeling and increase the knowledge about food among consumers. It is hard to believe that each consumer will improve own skills to become a food specialist.

4. Food safety policy

The global, regional, or national food safety policies are currently based on a combination of voluntary tools and mandatory measures imposed by FAO, EFSA or Department of Agriculture in a given country. In addition, some supplementary systems were imposed. Recent food scandals occurring around the world and especially in EU and Japan have raised concerns about the adequacy of protection measures designed to assure food safety (both voluntary and mandatory) along entire food chain - ‘from the farm to the fork’ for consumers. The food chain could be divided into several processes and sub processes, each of which is under control of various owners and associated with risk. Studies by Slovic (1987) and Slovic at. al. (1985) have shown that perceived risk is both predictable and quantifiable. Some processes are under control of farmers, other are controlled by producers and suppliers or retailers and finally, by consumers.

Several voluntary systems of food safety assurance were invented and implemented in various organizations along food chain: GHP (Good Hygienic Practice), GMP (Good Manufacturing Practice) and GLP (Good Laboratory Practice). The last one was very important for analytical and new product testing laboratories. Also, in several countries GAP (Good Agricultural
Practice) systems were applied. The natural expansion of those systems and requests for more safe food evolved into HACCP system. At the early beginning HACCP was voluntary.

After Denmark, other countries introduced and developed “clones” of HACCP as national standards, each with its own interpretation and associated documents. This led to numerous confusions, especially along the complex food chain. The response to this issue is ISO 22000 (2005) standard, which will use the best of ISO 9001 and HACCP and has the potential to become a global standard. ISO is a worldwide organization with a high involvement of undeveloped, developing and developed countries (Zalewski et.al., 2005). The advantages will be numerous: more dynamic and efficient control of food safety hazards, documentation will be unified, post-process verification will be reduced, flow of information in food chain will be simpler. There is no doubt that the new standard will make the food safety standards landscape less complex and will add cost to all suppliers, especially medium and small enterprises. The impact of ISO 22000 will depend generally on two forces: market (consumers and retailers) and regulatory bodies, which in US and Asia are in favor of it.

For the time being, HACCP is an obligatory food safety system in all member states of the European Union and many other countries. The quality management system ISO 9001 is not obligatory in the area of food processing, unless authorities state otherwise.

The retailer “party” in 2000 launched Global Food Safety Initiative private safety standard. It is created and applied through agreement and than imposed on suppliers to prevent future food scares (Menard et al. 2005). GFSI is dominated by Britisch BRC and German IFS standards. This complexity might increase the chance of ISO 22000 standard in future.

The European Union created an objective tool for examining food safety in a form of official food safety control system based on variety of regulations e.g. directive 89/397/EEC (14.06.1989) on official food control, directive 93/99/ EEC (14.06.1993) on hygienic aspects of food, directive 89/396/EEC(1989) on withdrawing unsafe food from the market, scientific
proves, risk analysis etc. The aim of this system is protection of public and consumer health on the highest level (White Paper 2000, Green Paper). Responsibility has been shifted to EFSA (European Food Safety Agency) which started in 2002, sanitary and phytosanitary inspection, veterinary inspection, set of reference laboratories etc. and is under influence of state or regional authorities (e.g. the European Commission).

In addition the supplementary systems for monitoring food safety and risk are under operation or construction. We can mention ‘tracking and tracing’, RASFF (Rapid Alert System for Food and Feed), Global Food Monitoring System etc.

5. Case study: food safety in Wielkopolska region of Poland

Poland is a large country in Central Europe. Its area is about 311 000 km$^2$ and population reaches about 38 mln persons. Wielkopolska, a region in Western Poland, occupies 9.58 % of the country’s area and is inhabited by 8.80% of Poland’s population. It is a region with high agriculture, husbandry and food processing activity and efficiency.

Yield on basic cereals and potatoes per 1 ha is 116.7% and 121% respectively as compared to the whole of Poland. Livestock yield per 100 ha is 123.72% (cattle) and 258.06% (pigs) greater than the mean for Poland. Milk production is higher than mean by 17.80%. The share of food products and beverages manufacturing here is 15.09% (Statistical Yearbook 2004).

In this study we present the results of a survey conducted in the period 2003-2005 under the title ‘Efficiency of supervision system on chemical contamination of food’ (Gąsiorowska, 2005). 111 questionnaires were dispatched to selected medium and large food processing plants in Wielkopolska region. A return of 38% was achieved including 16-milk, 11-meat, 8-fruit and vegetables, 2-animal feed and 5-other enterprises. The responding factories applied a variety of quality management systems and safety systems: HACCP (83%), ISO 9001(20%),...
ISO 14001 (17%), other (2%). 83% of respondents have applied at least one system. All milk and animal feed processors had a laboratory facility. There were no laboratories in meat plants. In total 29 laboratories (in 42 enterprises) studied a variety of chemical and physical-chemical parameters in raw materials, during the processing process and final products. Content of fat, protein, acidity, dry matter, water, preservatives, dyes, heavy metals, nitrates (III, V), pesticides, drugs, minerals, DDT, polichlorobenzenes, dioxins and prions were most frequently analyzed.

However, the evaluation of chemical risk in food was supervised only accidentally, i.e. the range and frequency of analysis was governed by needs of external customers or by internal practice. There were no plans for monitoring chemical contamination. Thus, establishing strict rules by law is necessary in near future. The population of enterprises using HACCP system counts 26, and 23 out of them declared CCP. However, only 13 declared CCP for chemical contaminants. All milk processors (in or outside HACCP system) put stress on chemical composition and safety of milk. Laboratories in this sector were best equipped in the investigated sample.

According to the survey carried out, control units concentrate attention on obeying rules of GHP, GMP and HACCP and check the maturity stage of HACCP system. According to Polish law, all food processing factories are obligated to document at least that system is under preparation. There is no proof, however, of other cooperation, e.g. preparation of plans of internal control systems and risk analysis.

The structure of official food control units on regional level does not reflect the tasks. Frequently, there is overlap of competences and simultaneously some problems are not covered at all. The plans of analysis on national level obey general rules of European Union. The results of food examination are satisfactory and confirm its safety (microbiological,
chemical and physical). This optimistic conclusion does not mean that whole supervision system of chemical risk is efficient.

**Conclusions**

The authors developed the terms of food quality and food safety from food science and commodity science perspective. Food is an everyday necessary commodity and its parameters are evaluated from the position of both customer (subjective quality, narrow sense of safety) and producer/supplier (objective quality, broad sense of safety). Food safety policy has been visualized as a construct of voluntary, obligatory and supplementary systems propagating along food value chain and being under the impact of official food control. The efficiency of such complex system has been evaluated in the Wielkopolska region of Poland. It is a region with high agriculture, husbandry, food processing and trade activity. The results obtained indicate a potential ability of industry laboratories to serve a wide range of microbiological, chemical and physical analysis and assessment of food risk. However, risk assessment was supervised only accidentally, according to the needs of external customers, and without plans for monitoring contaminations. According to the survey results, official control units concentrate on checking if rules of GHP are obeyed and examine the maturity of HACCP system. The structure of such control system does not reflect the tasks and frequent overlapping of competences occurs. The results of food examinations are satisfactory and confirm its safety (microbiological, chemical and physical). This optimistic conclusion does not mean that the whole supervision system of chemical risk is efficient.
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