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## FOOD RISK ANALYSIS

**Abstract:** *Food risk analysis is very important. The risk management process is not only carried out in the event of a threat in the food consumed, but also at a time when there is no crisis situation - although during food crises it has a key role in dealing with panic and consumer health protection. Consumers see the risk in food associated with, for example, new technology, a new type of food (confront the risk with the benefits offered by new technology, product), food on which there are different opinions of specialists. In this paper the perception of food risk will be discussed as it depends on many characteristics such as: gender, level of education, age, income and others. In the next part of the paper the stages of food risk analysis will be presented: 1) risk assessment including: hazard identification, hazard characteristics, exposure estimation, risk characterization; 2) risk management: including risk evaluation, estimation possibilities, types of implementation, monitoring and review; 3) risk communication. In the third part of this paper tasks and responsibility in the field of risk communication will be shown.*

**Key words:** *food risk, food risk analysis, food risk perception, responsibility of risk*

### 1. Introduction

Risk is an inherent element of life. Usually food as a source of risk is perceived as low until food hazard appears. To illustrate the characteristic of risk nowadays, the piece of a book written by Ulrich Beck "Risk society" can be cited: "All the crises and threats of the past years, including mad cow disease (...) had one thing in common - they went beyond the limits of our imagination. Thus, our previous expectations and forecasts were subject to a major revision each time. The risk is that it can not be measured or observed in its pure form. Therefore, the analysis of the social development of the risk assessment process

is decisive, in order to be clear who and on what basis the given factor is considered a real threat, and ignores the other, in the conclusion that it is irrelevant. In accordance with the concept of risk, we usually take experience from the past as a starting point and based on it we create expectations as to possible cataclysms in the future". Firstly, some definitions should be given. There are many definitions of risks. For example risk can be characterized by consequences, exposure, hazard, and harm. Another definitions divide the characteristics of risks into two categories: "science-based" which includes costs, benefits, severity of illness, and probability of death, and "values-based" which includes the understanding,

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observability, familiarity, and controllability of the risk. According to the REGULATION (EC) No 178/2002 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety (Article 3, point 9 - 14):

- 'risk' means a function of the probability of an adverse health effect and the severity of that effect, consequential to a hazard;
- 'risk analysis' means a process consisting of three interconnected components: risk assessment,
- risk management and risk communication;
- 'risk assessment' means a scientifically based process consisting of four steps: hazard identification, hazard characterisation, exposure assessment and risk characterisation;
- 'risk management' means the process, distinct from risk assessment, of weighing policy alternatives in consultation with interested parties, considering risk assessment and other legitimate factors, and, if need be, selecting appropriate prevention and control options;
- 'risk communication' means the interactive exchange of information and opinions throughout the risk analysis process as regards hazards and risks, risk-related factors and risk perceptions, among risk assessors, risk managers, consumers, feed and food businesses, the academic community and other interested parties, including the explanation of risk assessment findings and the basis of risk management decisions;
- 'hazard' means a biological,

chemical or physical agent in, or condition of, food or feed with the potential to cause an adverse health effect; Introduction should provide a review of recent literature and sufficient background information to allow the results of the paper to be understood and evaluated. It should clearly explain the nature of the problem, previous work, purpose and contribution of the paper.

Within the CFIA (Canadian Food Inspection Agency) model context, a risk factor was defined as any condition or characteristic associated with a food product, process or practice that impacts (either by increasing or decreasing) the likelihood of occurrence of a food safety issue and therefore, the risk of disease or infection. As such, a risk factor should be independent of the type of product/commodity (e.g. meat, dairy), processing or activity (e.g., slaughter, processing) conducted at food establishments [Racicot M. et al., 2019].

The authors mentioned above on the basis of literature review managed to identify 155 food safety risk factors. These food safety risk factors were grouped into the following categories: hazard identification, hazard characterization, exposure assessment, risk characterization, social-political-economic situation, external risk factors, internal risk factors, risk factors relating to sampling, prevention/intervention, organization, risk factors relating to equipment, risk factors related to employees.

Food risk analysis is very important because food is consumed by each person and consuming food is a common activity. That's why the potential number of people suffering from the hazard in food can be enormous. On the basis of research done by i.e.

Eurobarometer [[http://ec.europa.eu/public\\_opinion/archives/ebs/ebs\\_354\\_fact\\_pl\\_pl.pdf](http://ec.europa.eu/public_opinion/archives/ebs/ebs_354_fact_pl_pl.pdf)] and G. Hawkes et al. [Hawkes G., Houghton J., Rowe G., 2009] people perceive food as a source of

risk as low. They pay more attention to risks connected to economy, health, environment. As S. Andrew Starbird, Gregory A. Baker [S. Andrew Starbird S., Baker E. A., 2019]: said the major difficulty associated with evaluating risk is that individuals, organizations, and public agencies define and perceive risk differently. For example, economists to define risk use costs; consumers use costs too but they refine their perception with issues such as: dread, lack of control, catastrophic potential, ease of reduction, outrage, inequality in a distribution of risks and benefits.

## 2. Risk analysis in food

WHO and the Food and Agriculture Organization of the United Nations (FAO) elaborated a risk-based approach for the management of public hazards in food products. The name of this approach is risk analysis, and is built of three components:

- 1) Risk assessment.
- 2) Risk management.
- 3) Risk communication

### 2.1. Risk assessment

Risk assessment is the scientific evaluation of known or potential adverse health effects resulting from human exposure to foodborne hazards. The process consists of the following steps:

- Hazard identification.
- Hazard characterization.
- Exposure assessment.
- Risk characterization.

**Hazard identification:** The identification of known or potential health effects associated with a particular agent.

**Hazard characterization:** The qualitative and/or quantitative evaluation of the nature of the adverse effects associated with biological, chemical, and physical agents which may be present in food. For chemical

agents, a dose-response assessment should be performed. For biological or physical agents, a dose-response assessment should be performed if the data is obtainable. In the case of biological and physical hazards, this relationship can be determined if data are available. Qualitative analysis is created using the opinions of experts in a given field. The qualitative analysis should include:

- define how important the threat is,
- determine how dangerous any illness can be,
- describe what are the consumer habits,
- outline the probability of a threat.

Considering the microbiological threat as an example, one should answer the following questions:

How dangerous can the disease be? How many microorganisms do you need for an infection? How does the occurrence of an infection depend on the state of health and age? Which population groups are more vulnerable to falling ill? What is the type of food? Are the microorganisms toxic?

**Exposure assessment:** The qualitative and/or quantitative evaluation of the degree of intake likely to occur. For example, in the case of a microbial threat, the number of microorganisms that can be consumed in one portion of food without any side-effects of health should be determined. One of the methods of estimating exposure is the Monte Carlo simulation method. This method takes into account such variables: storage time, initial number of microorganisms, time and volume of consumption. By compiling these variables, you can receive the probability of consuming a quantity of product that can cause food poisoning. Simulations can be carried out according to three scenarios: pessimistic - for groups particularly sensitive to infection, intermediate - for the average consumer, conservative - for particularly resistant groups [Kołóżyn - Krajewska D.,

2007].

$$N_t = N_{0e}^{\mu t}$$

$N_t$  - estimated number of microorganisms in the portion of consumed product,

$N_0$  - the initial number of microorganisms (in the portion of fresh product),

$\mu$  - growth factor,

$t$  - storage time.

For the purpose of exposure assessment the prognostic programmes can be used. By means of prognostic programs, it is possible to predict the time after which, under given conditions and in the case of a specific raw material / product, the pathogenic bacteria will increase to a level above the acceptable level. And thus decide whether the product / raw material poses a threat to consumer health.

Pathogen Modeling Program (PMP) The model is available on the US Department of Agriculture website (USDA). This program consists of 35 models, for 14 types of bacteria. After entering the relevant data (temperature, pH, water activity (or NaCl concentration)), you can determine the time of microorganism multiplication.

#### THERM 2.0 program

The Wisconsin-Madison University website has a program to predict the growth of pathogenic bacteria in various types of meat. Data in this program are based on the results of research carried out at the University. After entering the storage time and storage temperature, the program allows you to determine if the bacteria will grow (*E. coli* 0.157, *Salmonella*, *Staphylococcus aureus*).

#### Combase

A further example of such programs may be the ComBase database ([www.combase.cc](http://www.combase.cc)) (Com Base Predictor tool). It was developed on the initiative of cooperation of the Institute of Food Research (IFR) in Norwich (Great Britain), the American Department of Agriculture (USDA) and the Australian

Center for Food Safety (FSC) (<http://www.combase.cc/index.php/en/about-Combas>)

**Risk characterization:** Integration of hazard identification, hazard characterization and exposure assessment into an estimation of the adverse effects likely to occur in a given population, including attendant uncertainties. Prepare the probability distribution of the exposure. It is not possible to achieve total safety - you need to determine the acceptable risk of disease in a given population. It is necessary to adjust the level of acceptable risk to the seriousness of the threat (eg the level of safety in the case of *Clostridium botulinum* must be significantly higher than in the case of less dangerous microorganisms) The acceptable level of exposure to *Clostridium botulinum* in the food is determined at less than 1 can for  $10^{12}$  packages, and in the case of non-life-threatening micro-organisms, 1 spoil for  $10^4$  packages is responsible for spoilage) [Kołóżyn - Krajewska D., 2007]. During the risk characterization stage, the analysis of the size of risk and the costs needed to minimize it should be taken into account. On this basis, the level of security is determined - it is necessary to be used for particular technological operations. It should also be remembered that as a result of reducing the risk to one threat, do not increase the risk of another factor.

#### **2.2. Risk management**

The risk management process is not only carried out in the event of a threat in the food consumed, but also at a time when there is no crisis situation - although during food crises it has a key role in combating panic and consumer health protection. Consumers see the risk in food associated with, for example, new technology, a new type of food (confront the risk with the benefits offered by new technology, product), food on which there are different opinions of

specialists.

## 2.2.1 Principles of food safety risk management

According to FAO there are eight general principles of food safety risk management (<http://www.fao.org/3/a-w4982e.pdf>):

1. Risk management should follow a structured approach.
2. Protection of human health should be the primary consideration in risk management decisions.
3. Risk management decisions and practices should be transparent.
4. Determination of risk assessment policy should be included as a specific component of risk management.
5. Risk management should ensure the scientific integrity of the risk assessment process by maintaining the functional separation of risk management and risk assessment.
6. Risk management decisions should take into account the uncertainty in the output of the risk assessment.
7. Risk management should include clear, interactive communication with consumers and other interested parties in all aspects of the process.
8. Risk management should be a continuing process that takes into account all newly generated data in the evaluation and review of risk management decisions.

## 2.3. Risk communication

The key role is played by informing consumers about the risks in an appropriate way, taking into account the fact that consumers (as the one who has less knowledge about food than experts) perceive food threats in a different way than specialists in this field. The way in which the risk is communicated to the consumer shapes the consumer's awareness of the risks

associated with consumed food. Higher consumer awareness in this field leads to greater involvement in the risk management process, both at the individual level (eg through conscious selection of food products, maintaining hygiene rules during meal preparation), as well as social (eg cooperation with institutions responsible for food safety) ) [Strada A., Sikora T., Adamus W., 2006].

Communicating the food safety risk should begin with answering two basic questions that shape the type of risk communication:

1. What should you communicate?
2. Who is the recipient of this message.

When building a risk communication, these elements should be taken into account [The application of risk communication to food standards and safety matters, Report of a Joint FAO/WHO Expert Consultation Rome, 2–6 February 1998,]:

- type and severity of the threat,
- what is the harmfulness of the threat,
- whether the situation requires immediate action,
- whether the risk of danger will increase / decrease,
- how many people are at risk, whether it is the whole society or selected groups,
- what methods the risk was estimated,
- what actions have been taken to minimize the risk of what activities can be undertaken by consumers.

It is important to inform consumers about the risks associated with consumed food also when there is no risk, but anxiety among consumers can be observed. When preparing a risk communication strategy in such situations, please pay attention to:

1. Information from consumers:
  - find relevant, in the opinion of consumers, issues related to the

perceived risk of food hazard before it becomes a serious problem,

- determine what consumers consider a threat,
  - define the group of interested recipients, what information they need.
2. establish a risk communication method. Preparation:
- define consumer groups, their expectations as to information,
  - prepare the information transfer in a manner understandable to consumers,
3. Provision of information:
- information should be provided using the media,
  - it should be a two-way process - from experts to consumers and from consumers to experts,
  - educate consumer programs.
4. Evaluation:
- an evaluation of the implemented strategy should be made,
  - check whether the information provided has been understood by consumers,
  - combine risk communication with risk assessment and risk management,
  - provide training for people involved in risk assessment and management.

Co-operation between governmental, non-governmental entities and the private sector is necessary.

In a situation where there is a threat to food safety available to consumers, proper risk communication is important because it prevents panic among consumers and provides information on the current

situation. This information applies to:

- the nature and scope of the threat,
- the actions that have been taken to estimate it,
- sources of food contamination and handling "uncertain" products, characterizing the threat, data, where and how to seek medical help, if needed,
- how to prevent the threat from spreading,
- how to deal with food products in the event of a threat in food.

There are health threats that have been identified recently, eg mad cow disease, where the effects are late, there may be threats so far unknown, therefore the precautionary principle has been introduced - this is an approach to risk management under conditions of scientific uncertainty, which takes into account the need to act in the face of potential risk, without waiting for the result of scientific research. The precautionary principle is an expression of a conservative approach in dealing with a given threat [ Tyszkiewicz S., 2000].The precautionary principle was introduced into EU legislation in the Treaty of Amsterdam (June 17, 1997, it came into force 1.05.1999).

### 2.3.1.Principles of risk communication

When communicating to consumers, the risk should be followed as follows [The application of risk communication to food standards and safety matters, Report of a Joint FAO/WHO Expert Consultation Rome, 2-6 February 1998,]:

1. Knowledge of the group to which the message is directed.
2. Involvement of experts in the process of risk communication.
3. Knowledge and the ability to reconcile the interests of all interested parties.

4. A reliable source of information.
5. Division of responsibility in the process of risk communication (state, producers, controlling units, media).
6. In the communication process should be given facts about the threat, avoiding valuation. You need to know what level of risk is acceptable to society.
7. Transparency of the risk analysis process, interactive communication of knowledge
8. with interested parties.
9. Long-term view - eg what benefits new technology will bring compared to the risk, comparison of new risk with similar ones.

Methods for communicating risk are key to the consumer's traceability and labeling of food products [Houghton J.R., Rowe G., Frewer L.J., Van Kleef E., Chrysoschoydis G., Kehagia O., Korzen-Bohr S., Lassen J., Pfenning U., Strada A., 2008]. Risk is also important in communicating risk. A specific feature of trust is that its need is revealed only in conditions of uncertainty and risk and lack of sufficient knowledge. Between trust and risk, a difference is outlined - a person takes a risk after considering all the benefits and effects, if the benefits outweigh the negative effects, take action. This decision is made on the basis of his knowledge, experiences, similar situations that took place in the past. In building trust, it is worth remembering that the views, concerns and expectations of each party should be taken seriously. Building trust is a long-term process [FAO Expert Consultation on food safety: Science and Ethics, Rzym, 2002, <http://www.fao.org/docrep/006/j0776e/j0776e00.htm>].

Communication of food risk should be adapted to the knowledge, expectations and moods of the society. Consumers should be made aware of what has been done, what

steps will be taken. Between trust and certainly there is a positive dependence. If the risk information is communicated by a person, an economic entity, an institution that consumers trust, they feel more confident, they believe this information. For operators in the food chain, consumers they trust the food producers the most (more than, for example, farmers, distributors, the government, it may be due to the fact that in the opinion of consumers, producers are the most responsible for food safety). Manufacturers' concern for the good of the consumer is the most important factor in building trust. If risk communication is carried out by an entity that consumers do not trust, but is perceived as responsible for food safety, consumer uncertainty increases. Therefore, such communication is aimed at calming consumers, increasing their certainty, quite the opposite effect. The sense of confidence among consumers influences the assessment of competence, integrity of risk communication [De Jonge J., van Trijp J.C.M., van der Lans I.A., Renes R.J., Frewer L.J., 2008].

### Tasks and responsibility in the field of risk communication

The state, producers and distributors of food, consumer organizations, consumers and the media have specific tasks and responsibilities in the process of communicating food-related risks. Country [Sikora T.: Bezpieczeństwo żywności, komunikowanie ryzyka konsumpcji żywności a zaufanie konsumenta, 2004].

- The application of risk communication to food standards and safety matters, Report of a Joint FAO/WHO Expert Consultation Rome, 2–6 February 1998, <http://www.fao.org/docrep/005/x1271e/x1271e00.htm>]: establishment of food law,
- risk analysis,

- ensuring adequate risk communication tailored to the target group,
- official food inspection,
- consumer education.
- New agri-food chain structure [Hans J.P. Marvin et al., 2016].

Producers / distributors:

- ensuring food safety,
- risk communication,
- ethics in the food business.

Consumer organizations:

- participating in the process of risk communication, representing consumer interests,
- consumer education.

Consumers:

- needs,
- expectations,
- self-education.

Mass media:

- transmission of information about the threat,
- educating the consumer,
- information ethics.

**Food safety risks**

European Commission has identified the key drivers to food safety and nutrition risk (FCEC 2018):

- Global economy and trade;
- Global cooperation and standards settings;
- Governance;
- Demography and social cohesion;
- Consumer attitudes and behavior;
- New food chain technologies;
- Competition for key resources;
- Climate change;
- Emerging food chain risks and disasters

Consumers perceived food risk in a different way than experts do. Research that explore consumers perception of expertly defined risks show that consumers overestimate risks posed by some hazards and underestimate other. Food risk are commonly framed as threats to safety or quality. According to another distinction there are modern and traditional risks. Traditional risks are those risks that have always been present in nature, not created from human control. Traditional food risk can be defined as food microbial contamination and spoilage. On the other hand, risk produced by human technologies, intervention and due to human decision making are called modern risks. These risks have bigger scope of impact and are more difficult to see, contain and manage. Modern risk come from food biotechnology, food additives, chemicals, pesticides [Tonkin E. et al., 2016].

Many factors influence the perception of risk, including food-related risks. Among them, one can distinguish:

- sex,
- age,
- education level,
- income
- -he number of people in the household, the role played in the household,
- number of children and their age,
- individual characteristics of the consumer.

According to a study carried out by M. Finucane et al. [Finucane M. L., Slovic P., Mertz C.K., Flynn J., Satterfield T. A., 2000] men perceive the risk as smaller than women. Such regularity also takes place among scientists and specialists in a given field, although they have knowledge about the issue. White people also assess the risk lower than people of other races. In addition,



it can be concluded that men and women of a different race than white also perceive the risk, which can not be observed among the Caucasian race - the discrepancies in the perception of risk are significant. Caucasian men rate the risk lower because they are able to hierarchize risks and trust in new technologies. The perception of food as a source of danger is also influenced by the presence of children in the household. Respondents who live in a home with children attach a much greater role to food hazards than those who live without children. Respondents raising young children pay special attention to food as a source of danger. Housewives who deal with home every day attach more importance to food safety than women who work outside the home. Young consumers generally perceive the risk as smaller. Among people over 55, there is a tendency to assess the risk as being greater. Taking into account the level of education - people with a higher level of education, perceive food-related risks as smaller. The same relationship is in the case of income - the higher the income, the lower the degree of risk perception, which can be explained by the possibility of purchasing products (usually more expensive), which in their opinion are safer or minimize the risk.

It is worth noting that men are usually responsible for determining the food safety policy. Men tend to assess risk as being lower than women because they think they can control the situation. Such a disposition means that men do not perceive risk where women see it, which is why their views do not reflect the opinion of the whole society [Dosman D. M., Adamowicz W. L., Hrudehy S. E., 2001]

The consumers' perception of food-related risks depends primarily on their knowledge in this area [Ozimek I., Gutkowska K., Żakowska-Biemans S., 2004]: Paradoxically, it can be said that the more knowledge about the health risks from the food the person has,

the greater the uncertainty as it takes into account various aspects [Järvelä K., Mäkelä J., Piironen S., 2006].

The method of risk communication plays a significant role in the process of shaping consumer awareness about food hazards. Consumers' awareness of the risk of food safety risks can not be defined as the level of expertise. Consumers assess the risk subjectively. If the consumer makes an assessment, it is difficult to change it later, because he will look for evidence consistent with his imagination.

Understanding how consumers perceive the risk of food safety plays an important role in minimizing or avoiding losses, including economic ones, that may come to light when information on food emergencies is published in the mass media [Jakubowska D., Radzyńska M., Smoczyński S. S., 2010].]. In addition to economic losses, there are also expenses related to risk management and rebuilding customer trust in the company / product. Consideration of risk perception among consumers should also be carried out in situations where there is no risk in food, in this case one can infer about the process of risk perception, food issues that cause special concern in society and on this basis develop a risk communication method .

The perception of risk size among consumers can be classified into one of three categories:

- the risk associated with technology is more difficult to accept than the risk caused by our activities,
- our risk of meeting the problem is lower than average,
- known risk is less dangerous than unknown.

The perception of risk is subjective depends, among from the psychic characteristics of the person, knowledge, the subject to be a source of risk, experience, etc. Risk perception refers to the consumer's

estimation of how likely it is that he or she will be exposed to hazards and what the severity of the threat is. Consumers usually assess the risk focusing on the severity of the effects rather than the likelihood of a hazard [Yeung R. M.W., Morris J., 2006]. Vulnerability is associated with the consumer's willingness to take risks. Consumers do not have such knowledge about food as experts in this field, which is why they perceive risk differently. Consumers recognize the risk in many aspects, take into account many factors, such as ignorance of the threat, harmfulness, influence on the next generations, the ability to control. Variability in the perception of food risk can be characterized by: harmfulness, ignorance of the threat, number of people exposed to risk [Hansen J., Holm L., Frewer L., Robinson P., Sandoe P., 2003]. As van Dijk H. et al., 2008 said consumers prefer regulatory authorities with responsibility for consumer protection to direct their efforts towards preventing the occurrence of a food safety incident, as opposed to managing risks through adoption of a reactive approach.

Integral part of risk analysis is science-based approach which role is to improve food safety systems and good quality practices. Risk analysis strengthens the ability of traditional food safety systems to meet current challenges (Chapter 5: Role of risk analysis and risk communication in food safety management, 2017).

Konstantinos P. Koutsoumanis, Zafiro Aspidou, 2016 emphasize that food safety management at international level has been moved towards a more risk-based approach. A risk based food safety management system can be built of four steps: 1) preliminary risk

management activities, 2) identification and selection of risk management options, 3) implementation of risk management decisions, 4) Monitoring and review.

The risk-based approach offers advantages for food safety chain actors. It enables the assessment, management and communication of risk.

## Conclusions

Food risk as each risk is a very complex issue.

There are many factors influencing food risk perception,

Consumers perceive risk connected to food as low.

Perception of food risk vary based on the type of product, for example the highest risk is perceived for meat and meat products, the lowest for fruit and vegetables.

Food risk can be divided in for example two categories of risks: traditional and new.

Consumers have less knowledge about food risks than experts that's why they perceive food risks in another way. Consumers sometimes overestimate or underestimate food risks.

Food risk analysis should be a continuous task.

New food risk may appear.

Properly elaborated communication of risk has a big role to inform consumers, avoid panic and loss.

Risk-based approach should be a part of food safety systems and standards.

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