



## Risk perception related to food

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### Abstract

There is no human activity that is risk free, including those most trivial and essential for survival, such as eating. Various factors impact the risk perception of a population, such as whether the risk is voluntary, known, brings some benefits or whether the information about the risk is provided by sources seen as trusted. Furthermore, regional and cultural aspects, gender and age can also have an impact on risk perception, and the level of scientific knowledge of the individual about the risks has in many cases little impact on the risk perception. In most countries, the perception of consumers to certain risks present in food, including genetically modified organisms (GMO), pesticides and food additives is high, probably due to the lack of confidence on the industry and governmental authorities that are responsible to control the risks. Food that are considered more natural, such as organic food and “GMO free”, are normally perceived as less risky/more healthy. Knowing the perception of the population regarding the risks present in food is essential to design clear and transparent risk communication strategies, which should consider, in addition to scientific information, the subjective aspects that affects the risk perception.

**Keywords:** risk perception; food; contaminants; pesticide residues; technology.

**Practical Application:** To help governments in their strategies of communicating to the general population about the potential risks present in food.

### 1 Introduction

The subject of risk has taken a central position in health areas in recent years, involving experts and the general population in the debate, due to the direct impacts on people's daily lives (Spencer, 2016; Castiel et al., 2010).

The term “risk” probably comes from the Greek word *rhiza*, in reference to the hazards of sailing around a cliff, with the possibility of scratching the ship hull (Covello & Mumpower, 1985). More recently, risk was defined by Beck (1992) as a situation or event in which something of human value (including humans themselves) is at stake and where the outcome is uncertain. Sandman (2012) defined risk as a function of hazard and outrage ( $R = f(H,O)$ ), where hazard can be a chemical, a bacteria or a poison gas and outrage involves factors such as trust, fairness, familiarity and memorability. For Kermisch (2012), the concepts of risk and responsibility are increasingly intertwined, a tendency that has grown by increasing public awareness, and suggested that a form of virtue-responsibility should be integrated in the concept of risk. Indeed, risk has a polysemic nature, whose objective and subjective dimensions must be understood as complementary, considering the technical and social components, being socially, culturally and mentally constructed (Covello & Mumpower, 1985; Hansson, 2010; Völker et al., 2017).

The first risk perception studies appeared in the 1970s (Renn et al., 2001), and several definitions are available for this term. It may refer, for example, to subjective assessments of the likelihood of a particular type of incident occurring (Cho et al., 2014) or to the ability to interpret a situation of potential harm to

one's health or life based on past experience and extrapolation to a future moment (Wiedemann, 1993). There are several theories or approaches to investigate risk perception within a population (Spencer, 2016). One of them is the psychometric paradigm, which initially sought to determine how people perceived technological risks in relation to their benefits, considering social and psychological contexts, seeking to answer “How safe is safe enough?” (Starr, 1969). Subsequently, Slovic et al. (1980) postulated that individuals perceive situations as safe or risky depending on the context of the risk, such as whether it is voluntary or imposed, known or unknown, whether there are benefits involved, or whether the information comes from reliable sources (Lanard, 2004; Sandman, 2012). Visschers & Siegrist (2018) emphasized that these aspects have different impacts on risk perception to different hazards.

Food is essential for body development and life-sustaining, and health promotion and disease prevention through healthy diets have been increasingly recognized as crucial in the contemporary world (European Commission, 2014). The act of eating also has a strong social connotation, closely related to family unity, religious festivities and the most diverse forms of integration (Kaptan et al., 2018; Frewer et al., 2016). Although foods offered to the population are considered safer than in the past, episodes in recent decades, such as the mad cow disease (Bovine Spongiform Encephalopathy) in England in 1986 and Avian Influenza in Asia in 2003, have undermined consumer confidence in health and control authorities, bringing uncertainty about food safety

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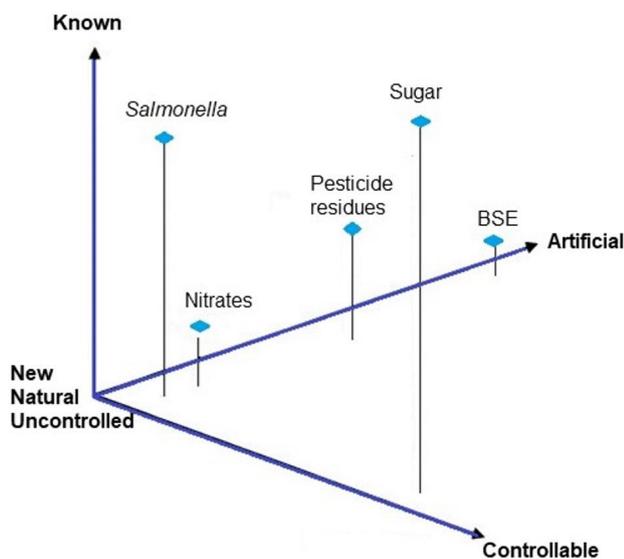
(Bánáti, 2011). In addition to scientific information, knowledge of how consumers perceive the different risks they are exposed to in their diet and how this influences their consumption decisions is important for the design of efficient governmental risk management and communication strategies (Charlebois & Summan, 2015; Hooker et al., 2017).

This study aimed to investigate food-related risk perception from studies conducted in the world in recent decades, a subject that is still little explored in Brazil. Food-related risk perception of genetically modified organisms (GMOs), pesticides and food additives will be discussed in more detail.

## 2 Food-related risk perception

Food-related risk perception acts by cognitive mechanisms. They may differ from non-food risks, essentially because food is a vital necessity and part of people's daily lives (Kaptan et al., 2018). Some determinants seem to be particularly important in shaping people's reactions to food risks. For example, foods of technological origin are perceived as more dangerous than natural foods (Frewer et al., 2016), although the perception of what is natural is not always the same among people (Chambers et al., 2018). Additional complexity stems from acute *versus* chronic risk. For example, presenting a naturally occurring risk in an acute or crisis context (such as poisoning events) may exacerbate risk perception, while technological risks are most feared for their possible (or perceived) long-term chronic effects (Glik, 2007).

Sparks & Shepherd (1994) and Fife-Schaw & Rowe (1996) pioneered the application of the psychometric paradigm in food-related risk perception studies. Figure 1 shows three dimensions of risk perception in light of the psychometric paradigm: natural x technological, controllable x uncontrollable and new/unknown x old/know (Breakwell, 2000). It is observed that sugar is in a high position on the knowledge and risk controllability axis and is also recognized as a natural substance.



**Figure 1.** Three dimensions of risk perception of food hazards. Adapted from Breakwell (2000). BSE: Bovine Spongiform Encephalopathy.

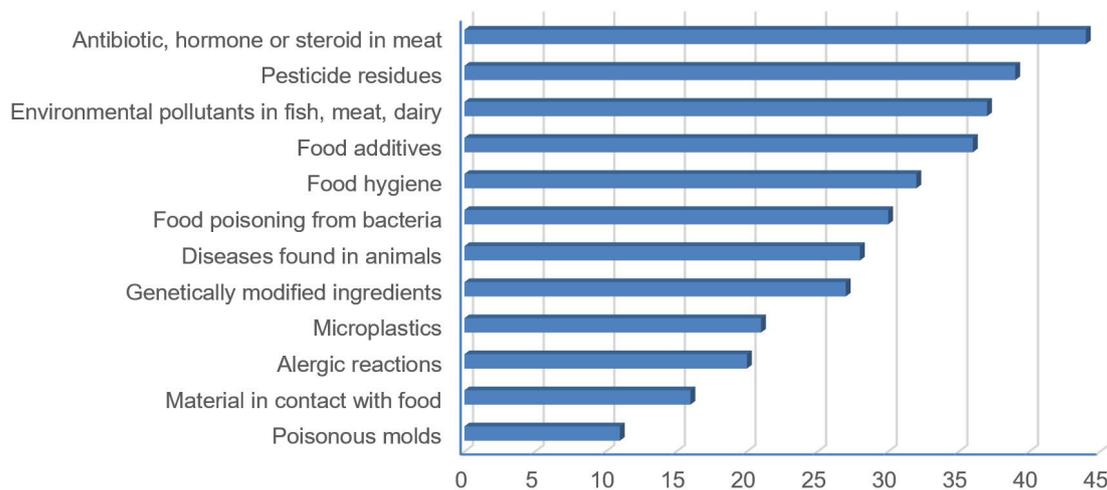
However, pesticides lay in a low to moderate level of knowledge, no controllability, and more perceived as technological/artificial rather than natural in origin.

Breakwell (2000) also suggested that gender (women tend to be more aware of food risks), ethnicity, age, and geographic region may be potential sources of variation in risk perception. In South Korea, You et al. (2018) examined perceptions about four hazards (benzopyrene in noodle soup, norovirus in school cafeterias, misuse of plastic coffee bags and salmonella in children's foods) against five psychometric factors (familiarity, confidence, catastrophic potential, effect on children and dread). Confidence, catastrophic potential and dread impacted all hazards, and all factors affected norovirus-related perception. Confidence was the factor that most affected the risk perception for children's food (salmonella and norovirus).

The European Union periodically conducts a survey with several population extracts on various human activities, including perception on food-related risks, called Eurobarometer. In the 2010 Eurobarometer (European Commission, 2010), 19% of citizens had spontaneously mentioned the presence of pesticides and other chemicals in food as factors of concern, leading the list of risks mentioned. In the most recent study conducted in April 2019, 27,655 *vis-a-vis* interviews were conducted in the 28 member countries (European Commission, 2019). About 40% of respondents said they had a personal interest in food safety and 55% showed a high level of awareness about food safety. There were significant differences in risk perception across countries, but 43% of respondents believed that food products are full of harmful substances. Greater familiarity (72% of respondents) was observed with food additives such as colorings, preservatives and flavorings. However, the major concern was related to antibiotic, hormone or steroid residues in meat (mentioned by 44% of respondents), followed by pesticide residues (39%), as shown in Figure 2. New topics such as microplastics first appeared on the continent's food safety radar (Figure 2).

In a study conducted with 26 European countries, Meagher (2018) suggested that national variations in risk perception are related to the influence of media coverage on food risks and adverse events, as well as strong food supply chain. Overall, there was greater attention and mobilization by activist groups on issues such as pesticides and hormones than on events of biological origin (such as the *Escherichia coli* outbreak in Germany in 2011). These events were perceived as more natural and personally controllable (Meagher, 2018).

Another study conducted in the European Union involved 6,000 respondents from 25 member countries and focused specifically on three emerging risks: green smoothies, plastic rice and nanotechnology (Etienne et al., 2018). Plastic rice was allegedly produced with potato, sweet potato and plastic and was widely mentioned in the media, although no real cases were identified. Results indicated that consumers tend to be more concerned with well-established risks, including fraud, than with emerging risks for which the population has little information. The study suggested that communicating information about the nature of the risk and the level of uncertainty associated with that risk could have an important impact on risk perception, mitigating or amplifying (green smoothie) that perception.



**Figure 2.** Main food-related topics that concern Europeans the most, % of respondents (European Commission, 2019).

According to the Netherlands National Institute of Public Health and Environment (RIVM, *Rijksinstituut voor Volksgezondheid en Milieu*), Dutch consumers eating habits are based on their perceptions, which do not always correspond to scientific knowledge. In general, consumers make no distinction between safe, healthy or sustainable food. There was a high concern regarding food additives and the perception that chemical risks were greater than microbiological or natural ones (Rijksinstituut voor Volksgezondheid en Milieu, 2017). In Ghana, consumers gave equal weight to concerns about the chemical *versus* biological hazards, both of which are marked by the majority as very or extremely concerned (Omari et al., 2018). Respondents were less concerned about aflatoxin contamination (genotoxic toxin produced by *Aspergillus sp. fungi*) and food produced near mining sites; women showed a higher level of concern/risk perception for most of the food hazards assessed than men (Omari et al., 2018). In a study involving US mothers, however, chemicals were considered to be of less concern than microbiological risks (cited by 12 and 51% of respondents, respectively), but the mere mention of “chemical substances in food” affected the decision to buy food by 63.7% of the participants (Petrun et al., 2015).

Using information obtained from 824 questionnaires in 16 Chinese cities and over 10,000 media reports on pork quality and safety, Yan et al. (2019) found that social activities coupled with media action affected consumers’ perceived risk regarding traceability in the food chain, in light of the social integration theory. The “ripple effect” proposed by the Social Amplification of Risk Framework (SARF; Kaspersen et al., 1988) was observed in groups that received negative food safety information from the media, but not in groups exposed to positive information.

In Brazil, food risk perception was approached by a study conducted in the city of Campinas, state of São Paulo and in the city of Rio de Janeiro, state of Rio de Janeiro through focus groups, preceded by a brief questionnaire to recruited individuals (Andrade et al., 2013). Consumer groups in both cities were very concerned about the presence of pesticides and heavy metals in food and about microbiological risks, particularly *Salmonella*. Meat, mainly due to hormones and nitrates/nitrites, and seafood

were considered foods with the highest health risk. The latter was of higher concern by Rio de Janeiro consumers.

A large study of risk perception associated with the food chain through focus groups involved consumers in Brazil and four European countries (Poland, Ireland, the Netherlands and France) (Kher et al., 2013). Overall, chemical hazards were perceived as of greater concern than biological hazards and were strongly associated with the potential for severe consequences, long-term effects and lack of personal control to prevent them. Of particular note is the greater concern of Polish consumers about the possible risks arising from food irradiation (used to control/eliminate the presence of microorganisms), which was attributed to Poland’s geographical proximity to Ukraine, where the Chernobyl nuclear disaster occurred in 1986. In the US, consumer perceptions of the food irradiation process also refer to the idea of nuclear energy/radiation, increasing the perception of individuals in this technology (Beareth & Siegrist, 2019). When the term food ionization was used in the American study, another denomination for the same technology, the negative perception on food quality was lower. This behavior is a typical example of affect heuristics, which holds that emotions and affective relationships influence our perceptions, judgments and decision-making (Kahneman & Frederick, 2005).

In a study conducted in Switzerland, Hartmann et al. (2018a) noted that food control experts, industry representatives and consumers reported varying degrees of prioritization for certain risks. Experts gave higher priority to day-to-day hazards such as nitrosamines in mascara and chrome in leather, while producers and consumers prioritized the risks posed by pesticides and GM foods. The authors recommended to regulatory authorities that, in addition to the objective results of the risk assessment, also consider the population’s food risk perceptions in prioritizing their actions. In Australia, Tonkin et al. (2016) observed that the population positively perceives food labeling as an effective risk communication instrument, and that it is imperative that actors involved in the food system ensure labeling information reliability. Hartmann et al. (2018b) indicated that labeling a food product with the expression “free from” shapes people’s perceptions, being viewed as healthier or safer by the public, as “GMO free”.

### 3 GMO-related risk perception

Although several studies have proven the safety and benefits of new technologies in the food production and industry, such as transgenic food (Bruetschy, 2019), public debate involving GMOs goes beyond science. The debate permeates sociocultural and affective contexts, and the acceptance of this technology is affected even by beliefs in food sacredness (Mallinson et al., 2018). According to Chen (2018), the rejection of food from new technologies (technological neophobia) shapes people's risk perception regarding GMOs.

In a review of European and American studies, Wunderlich & Gatto (2015) noted that although genetically modified foods were introduced more than 2 decades ago, there is still a low level of knowledge and awareness of basic GMO concepts. This contributes to a negative view by an important portion of the population on this topic. On the other hand, individuals reported a higher level of confidence in sources of information from scientists, albeit via the internet, TV and magazines, compared to government sources, activists, industry and the media. A greater familiarity with the term GMO does not necessarily imply scientific knowledge about it but correlates with rejection of the technology and consequently a desire to pay more for non-GMO products.

In a study conducted through the application of online questionnaires, Komoto et al. (2016) noted that Japanese consumers have a higher risk perception of GMOs than British and American consumers, but lower than that of the French. Overall, women, individuals over 60, and uneducated individuals were the groups most resistant to the application of genetic modification technologies to food in the four nations. Loebnitz & Grunert (2018) observed that abnormally shaped (deformed or very large) vegetables are seen in Germany as unnatural and GMO-related, increasing their risk perception. On the other hand, Eurobarometer results showed that Europeans are currently less concerned about GMOs when compared to the 2010 survey (European Commission, 2010, 2019).

In Brazil, a telephone poll conducted in 2016 showed that 44% of the consumers believe GM foods are poorly tested, 33% that they are bad for their health and 29% that they cause allergic reactions (Conselho de Informações sobre Biotecnologia, 2016). However, 73% said they had already consumed GM foods, and of the remaining, 59% were open to experimenting. Castro et al. (2014) assessed the public perception on GMOs involving about 800 Brazilian urban consumers from seven cities in different regions of the country. About 37% of respondents said they do not know what GM foods are, and among those who claimed to have at least a notion about the subject, a low risk perception predominated for these foods. Most of those who reported concern linked their risks to more intensive pesticide use, while advocates argued otherwise. The authors noted that there was some confusion of concepts (e.g., transgenics being confused with trans fats). They stressed the importance of separating the debate between "transgenic vs. non transgenic" and "organic vs. conventional".

### 4 Pesticide risk perception vs organic food benefit

Demand for products from organic agriculture, which do not use chemical pesticides for pest control, has been increasing worldwide since the 1990s, due to the increased environmental awareness and the perception that these foods would be healthier than conventional foods (Saba & Messina, 2003; Koch et al., 2017; Patel, 2018).

A study conducted in Denmark confirmed consumers' perception that organic foods are healthier, which was more related to the notion of purity ("uncontaminated") than to the nutritional value or pleasure of sensory experience (Ditlevsen et al., 2019). Hilverda et al. (2018) showed that the number of positive social media comments about a food in the Netherlands decreases the perception of its risk in situations of uncertainty, especially for organic foods. In another study of the group, determinants related to risk perception to these foods were positively correlated to the information sharing process, a behavior that should be considered in risk-benefit communication task (Hilverda & Kuttschreuter, 2018). In Germany, a computer-assisted telephone survey showed that both organic and conventional consumers viewed pesticides, chemicals, and toxins as the greatest threats to food quality and safety (Koch et al., 2017). About 70% of the organic consumers rated the risks of pesticide use greater than the benefits, compared with 53% of the conventional consumers. Organic consumers were significantly more concerned about pesticide residues in the food and in human fluids than conventional consumers.

Coulibaly et al. (2011) observed that consumers in Benin and Ghana demonstrated high perception of health risk from pesticide residues in fruits and vegetables, and were willing to pay more than 50% for pesticide-free foods. Similar results were found in a pilot study of 237 participants from the Federal District of Brazil involving outpatients, college students and supermarket consumers, when over 50% of respondents were willing to pay more for these products (Pimenta, 2003). In a more recent study conducted in the city of Belo Horizonte, state of Minas Gerais with 400 consumers, organic foods were associated with higher nutrient levels by 82% of respondents and being free of GMOs and synthetic chemicals by 75 and 86%, respectively (Andrade & Bertoldi, 2012). All related organic food consumption to health benefits and almost all (98.8%) reported improved health as a result of this consumption.

### 5 Food additives

Although food additives are useful ingredients in the food industry, with some benefits for consumers, being strictly regulated by governmental authorities, the rejection of their presence in food is increasing in the last decades (Szűcs et al., 2019; van Gunst & Roodenburg, 2019). In the Netherlands, food experts indicated that low reliability in the food industry and preponderance of negative information about food additives on the internet and social networks are the main causes of high risk perception (van Gunst & Roodenburg, 2019). The authors stated that forms of communication with the public, including labeling, need to be improved to overcome this barrier and increase acceptance of these substances. According to Rijksinstituut voor Volksgezondheid en Milieu (2017), an increased use of food additives will lead to a decrease in Dutch consumers' confidence in food safety.

A study carried out in Switzerland involving around 1000 participants showed that acceptance of dyes is lower than sweeteners, and risk perception to both additives was influenced by knowledge about regulation and trust in regulators (Bearth et al., 2014). Respondents showed lower risk perception in relation to benefit, and consequently greater acceptance of substances seen as natural. In Taiwan, where a series of scandals involving the addition of illegal food additives occurred, population perceptions and consequent rejection of foods containing chemical additives were quite high and were dependent on the frequency with which scandals were reported in the media and information source credibility (Chen, 2017).

In the study conducted by Pimenta in the Federal District of Brazil (Pimenta, 2003), 64% of consumers interviewed in supermarkets said they knew what a food additive was, but 87% considered them harmful to health, confirming that risk perception is dependent on other aspects than scientific knowledge. The same profile was observed among university students and patients (35.4/87% and 25/46%, respectively).

In the United States, Song & Schwarz (2009) reported that the difficulty in pronouncing the name of food additives, real or fictitious, was related to the perception of their risk. The harder it is to pronounce, the more the substance is perceived as harmful to health. Names that are more difficult to pronounce are usually substances considered new or less well known, and once they became known, judgment of their risk would be altered. Using the same method, this thesis was challenged by a study conducted with individuals from the Czech Republic, Germany, and workers from Amazon's Mechanical Turk (Bahnik & Vranka, 2017). The authors concluded that risk perception was more related to the size of the word than to the difficulty of pronouncing it. This perception ranged according to the context and encouragement received by the individual during the questionnaire application, such as war or leisure settings, confirming the subjective aspects of risk perception.

## 6 Conclusion

This review sought to show that people's perception of food risks is multifactorial and of great complexity, depending less on objective and tentatively measurable risks than on subjective issues. These issues comprise social, cultural, psychological, ethical and moral aspects, which together constitute what we call values or worldviews. Several studies on the subject have shown that, more than the rational and decisions based on technical-scientific knowledge, the emotional and intuitive side of individuals contribute strongly to the perception of food risks and their balance in relation to the benefits obtained. In this sense, risk communication strategies focused on filling scientific knowledge gaps tend to be ineffective if not aligned with approaches that consider and respect the human dimension that permeates the universe of perceptions.

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