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# Consumer awareness of meat hazards with special reference to sources of meat contamination and microbiological hazards

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**Abstract.** This paper presents the results of consumer opinion testing (n=1000) on hazards in meat (biological, chemical), as well as consumer opinion about causes of meat contamination from farm to retail. Consumer opinion on sources of meat contamination in households is also presented.

## 1. Introduction

Today's modern food safety system is based on production process hygiene and prevention of contamination with hazards. This system is supported by scientific and regulatory bodies all over the world and legalized in all developed countries. The modern food safety system is based on good manufacturing practices and good hygienic practices (GMP/GHP) and hazard analysis and critical control points (HACCP). The food producer is responsible for food safety and is required to identify hazards and reduce them to an acceptable level or eliminate them in order to make the product (food) safe for the consumer. The value of this modern approach to food safety is reflected in the fact that it encompasses all links of the food chain. It is understood that food safety depends on whether a defined safety system works in all segments of food production. Therefore, the entire food chain should be controlled and checked. The last links in the food chain are food retail, the place where the food becomes available to the consumer (restaurants, for example) and the consumer. However, absolute food safety, no matter how good, functional, controlled and checked the system is, cannot be ensured and guaranteed.

Foodborne diseases are not uncommon and they are, in most cases, caused by biological hazards, primarily bacteria. If these diseases are of an epidemic nature, it is understandable that they attract a lot of media attention and cause consumer concern. Foodborne diseases are not only a danger to human health and life, but also cause huge economic losses (sick leave, medical treatment). The key reasons for the high incidences of foodborne diseases related to households refer to consumer knowledge and information. Today's consumer should have knowledge of and be informed about food hazards, maintenance of workplace and personal hygiene, contamination pathways, food handling (storage



conditions and shelf life), food preparation methods, storage of prepared food and the importance of proper food waste disposal.

The aim of this paper is to examine consumer opinions about meat hazards, as well as knowledge of the main sources of meat contamination.

## 2. Materials and Methods

For the purposes of this research, a quantitative questionnaire was used to examine consumer attitudes about meat quality and safety. During 2017 and 2018, the survey covered the population from the areas of the city of Banja Luka and Gradiška (urban environments). Data were collected until 1000 validly completed survey forms were filled, which means that surveys that were not completed, or in which answers to questions were incomplete, were not taken into the data processing procedure. Demographic data about participants refer to: age, education and sex. The participants in the survey ranged in age from 20 to over 60, on the basis of which they were classified into five groups (intervals of ten years). In relation to education, the most numerous group in the survey were those with secondary education (53.10%), followed by respondents with tertiary education (38.9%), and the groups with the lowest participation in the survey were postgraduates (3.5%) and those with primary education (4.1%). Respondents were 45.80% females and 54.25% males.

Statistical analysis was performed using Chi square test to determine the significance of differences between means, as a basic statistical method for comparing the frequency of nonparametric landmarks. A level of 0.05 was considered significant. Statistical analysis of the obtained results was done in the statistical package GraphPad Prism software, version 8.00 for Windows (GraphPad Software, San Diego, California USA, www.graphpad.com). The results are presented in tables and graphs.

## 3. Results and Discussion

Consumer opinion about meat hazards is shown in Table 1. According to the respondents in the survey (several answers were possible), consumers believe that the greatest dangers are trichinosis (56.1%), GMO meat (53.3%) and salmonellosis (51.2%). This is quite understandable because these dangers are most often discussed in professional circles and the media [1]. There were significantly fewer responses concerning the two chemical hazards, the presence of hormones (35.3%) and antibiotics (33.9%), since they are less talked about, so consumers are less informed about these hazards. These two chemical hazards were significantly less ( $p < 0.05$ ) important for consumers choosing meat than the biological hazards.

**Table 1.** Significant hazards in meat in the opinion of the respondents (n=1000)

It is especially important for me to know that the meat I buy does not contain:	Answer (%)
Salmonellosis	51.2 <sup>A,B,C</sup>
GMO (genetically modified organisms)	53.3 <sup>D,E</sup>
Trichinosis	56.1 <sup>A,F,G</sup>
Hormones	35.3 <sup>B,D,F</sup>
Antibiotics	33.9 <sup>C,E,G</sup>

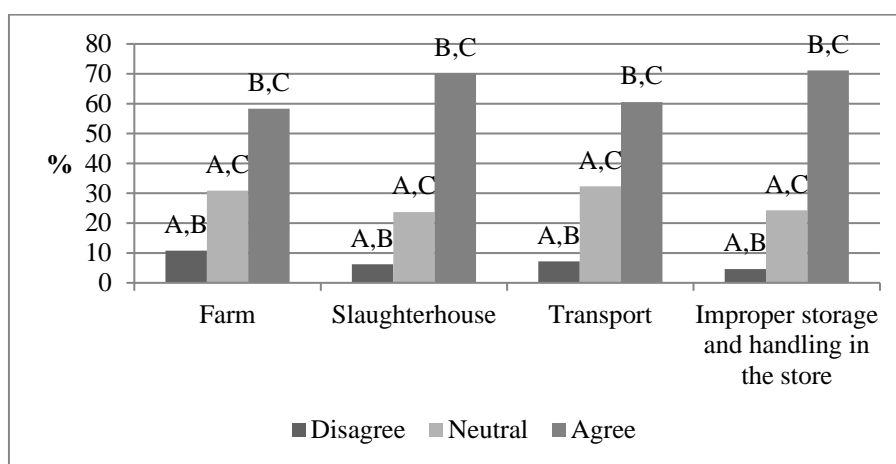
Same letters <sup>A, B, C, D, E, F, G</sup> -  $p < 0.05$ ; The total is more than 100% due to the possibility of giving more than one answer to the question.

Bernauer [2] in his research noted that the most significant barriers we face today regarding the adoption of GMO food by consumers are low confidence in the security of GMO food supply in important markets, such as the European Union, and relate to long-term health and environmental

consequences. Consumers are informed of the legal ban on the use of hormones and antibiotics in animal nutrition.

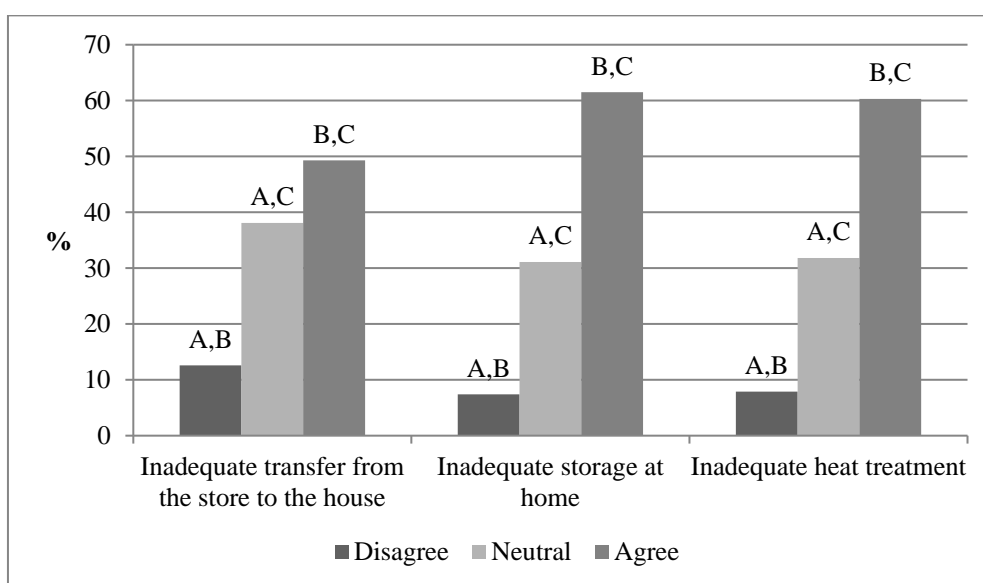
According to consumers, the most significant of the meatborne hazards are (in descending order): trichinosis > GMO > salmonellosis > hormones > antibiotics. The answers indicate that consumers are well informed about the biological and chemical hazards in meat.

According to the results of the survey (Figure 1), consumers think the main sources of meat contamination have the following descending order: inadequate storage and handling at point of sale > slaughterhouse > transport from slaughterhouse to store > farm. The declining number of the main sources of meat contamination in the household, according to consumers is: inadequate storage in the home > inadequate heat treatment > inadequate transfer from the store to the home (Figure 2).



Same letters A, B, C -  $p < 0.05$ ; the degrees of agreement were compared.

**Figure 1.** The main source of meat contamination from the farm to the consumer



Same letters A, B, C -  $p < 0.05$ ; the degrees of agreement were compared.

**Figure 2.** The main source of meat contamination in the household

Meat hazards according to the modern approach to food safety are divided into: biological (bacteria, viruses and parasites), chemical (pesticides, heavy metals, antibiotics, hormones and other environmental pollutants) and physical (glass, wood, plastic). Based on the conducted research, it can be concluded that the participants in the survey were aware of the impact that microbiological hazards have on health, that they are concerned about the consequences of consuming meat containing microorganisms, that the presence of microorganisms in meat can be controlled by laws and regulations, that microbiological hazards can be deadly, widespread, can spread rapidly with food, and cannot be easily controlled. Also, survey participants believe that there are not enough regulations related to microbiological hazards in meat, that they are not well regulated by law, that they are not sufficiently implemented and that consumers are not sufficiently informed about this issue [3,4,5,6].

Prevention of bacterial cross-contamination of meat/organs in slaughterhouses should be directed to good hygiene practice. In this regard, the introduction and acceptance of visual inspection of meat (no palpation or incision) itself has no effect on reducing bacterial contamination of the carcass/body under conditions of poor hygiene practices in slaughter in the house. If changes are noticed during the visual inspection of the meat, and in accordance with that, additional controls of the meat are performed by palpation and incision, then the transmission of bacteria can occur [7, 8, 9].

According to Zdolec [10], herd-level measures have a strong effect on the presence of *Campylobacter* spp., *Salmonella* spp., *Yersinia* spp., Shiga toxin-producing *Escherichia coli* (STEC) and two parasitic species *Toxoplasma* spp. and *Trichinella* spp. Serological categorization has a medium effect on the mentioned bacteria and parasites except STEC. Inspection has a limited effect on the presence of *Salmonella* spp., and a strong effect on the presence of *Trichinella* spp. (because examination is mandatory). Inspection is not relevant for the findings of *Campylobacter* spp., *Yersinia*, STEC and *Toxoplasma* spp. Slaughterhouse hygiene has a limited effect on the presence of bacterial species, and no effect on the presence of parasites. Carcass decontamination has a medium effect on the presence of bacteria, and no effect on the presence of parasites. Freezing has a medium effect on the presence of *Campylobacter* spp., a strong effect on the presence of parasites, and no effect on *Salmonella* spp., *Yersinia* spp. and STEC.

Fresh meat has a short shelf-life because its chemical composition favours the growth of many different types of bacteria. Meat contamination is possible at all stages of production and is the main source of bacteria that cause foodborne diseases [9, 11, 12]. The most common causes of foodborne diseases are *Staphylococcus* spp., *Listeria* spp., *Campylobacter* spp. and *E. coli*. Some of them, such as *E. coli* O157:H7, are highly pathogenic and only a few bacteria are enough to cause human disease. The main sources of meat contamination are the animals themselves, slaughter equipment, carcass processing and the workers in the slaughterhouse. The most common cause of carcass contamination is the skin of slaughter animals that is contaminated with faeces. The cause of contamination can also be related to contaminated water and improper application of good hygiene practice. Controlling the level of carcass contamination in the slaughterhouse can contribute to reducing contamination. The level of contamination in the slaughterhouse depends on the training of the workers, the frequency of training, regular health control of the workers, the use of protective equipment, the wearing of jewellery, the employee's health and the prescribed norms of sanitation. At retail market level, the level of bacterial contamination depends on the training of workers, the use of protective clothing, including hair protection, simultaneous handling of meat and money, wearing jewellery, application of detergents and the frequency of washing (daily or not) [12, 13].

According to Pal et al. [14], *Brochothrix thermosphacta*, *Pseudomonas* spp., *Aeromonas hydrophila*, *Bacillus cereus*, *Campylobacter* spp., *Clostridium* spp., *Listeria* spp., *Salmonella* spp., *Staphylococcus* spp., *Yersinia* spp. and *E. coli* are mentioned as meat contaminants. The consumer should be protected from pathogens in the meat and that there should be no health problems because of them. This can be achieved by respecting the principles of GMP, GHP and production process control (HACCP). Some biological hazards are related to particular types of meat, so two parasites (*Trichinella* spp. and *Toxoplasma* spp.) and two types of bacteria (*Salmonella* spp. and *Yersinia* spp.) are associated with pork meat, so this meat should be subject to continuous and systematic controls, according to EFSA

recommendations [15, 16]. *E. coli* and *Listeria* spp. are more commonly associated with beef, and *Campylobacter* spp. is most commonly associated with poultry meat. This, however, does not mean that they are not found in other types of meat [17, 18, 19, 20].

Iroha et al. [21] found in 300 examined samples (beef, poultry meat and horse meat) that 29.3% of the samples were contaminated with *Bacillus cereus*, *E. coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Shigella* spp. and *Staphylococcus* spp. In the examined samples, the most common of the studied bacteria was *E. coli* (8%).

Williams et al. [22] examined the possibility of bacterial transmission by packaging that is repeatedly used to transport purchased food. There is data that the packaging for the transfer of purchased food is used repeatedly (from two to seven times) in 51% of the examined cases of food supply. A large number of different types of bacteria were identified in the samples of the tested food transfer packaging, and coliform bacteria were found in half of the tested packaging, while *E. coli* was found in 8% of the tested packaging samples. From the results, it can be concluded that packaging plays a significant role in cross-contamination of food. This particularly applies when the same packaging is used to transfer food of plant and animal origin, which, according to a consumer survey conducted, occurs in 25% of cases. It was also determined that packaging is not washed in 97% of cases.

Gerba and Maxwell [23] report that the presence of *Salmonella* spp., *Campylobacter* spp., *E. coli* and *Staphylococcus* spp. in meat is often the result of cross-contamination, or failure to follow procedures with meat based on the principles of GMP/GHP. Meat contamination with these bacteria is beyond the control of households [1]. The most common bacteria in packaging used for food transfer are *E. coli*, *Klebsiella pneumoniae* and *Cronobacter sakazakii*. Coliform bacteria are usually indicators of faecal pollution and, in the premises, inadequate sanitation procedures for work surfaces, equipment and hands of workers during meat processing.

Among the viruses that cause foodborne diseases in humans, the Norwalk virus, rotaviruses, astroviruses, hepatitis A and hepatitis E viruses are important. The sources of infection are mainly people who come into contact with food. Foodborne fungi include *Cryptosporidium parvum*, *Cryptococcus neoformans* and zygomycetes. The group of biological dangers also includes prions that are found in some tissues of animals (especially in the nervous system) suffering from transmissible spongiform encephalopathies (such as bovine spongiform encephalopathy (BSE)). The causative agent of BSE is thought to have zoonotic potential [17].

#### 4. Conclusion

According to the test results, consumers most often associate the biological hazards, *Salmonella* spp. and *Trichinella* spp., with GMOs, because these dangers are best known to them from the work of state bodies and the media. Consumers believe that the most common sources of bacterial contamination are the slaughterhouse and improper food handling in retail. In households, consumers believe the greatest danger from bacteria comes from improper storage and inadequate heat treatment.

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