Importance of foodborne diseases

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Review

ABSTRACT

Preserving food safety in food chain, as well as the availability of world's food supply in terms of public health and global economy is one of the most important issues today. The globalization process which involves putting food on the world market enables hygienically unsafe food to be the cause of disease for a large number of people in different countries of the world at the same time. This paper presents data on the most significant bacterial pathogens of foodborne infections and intoxications, and their prevalence, notwithstanding the role of the World Health Organization and notification systems for cases of hygienically unsafe food on the market.

Key words: *food safety, foodborne diseases*

INTRODUCTION

Although there is still no globally accepted classification when it comes to food poisoning, the generally accepted division includes food infections and food intoxications. The term infection signifies the action of microorganism entered by food consumption (e.g. Salmonella, E. coli etc.), and the term intoxication signifies the state of the organism caused by toxin producing microorganisms in food (eg. Botulism) (Guerrant et al., 2001).

Although World Health Organization alerts to the fact that foodborne diseases occur much more frequently than ever before, control measures taken by competent authorities that are in charge of public health do not develop and do not follow with the same speed (WHO, 2007). The fact that approximately 30% of all emerging diseases in the past 60 years were caused by pathogens commonly transmitted through food is of great importance (Jones et al., 2008). When it comes to the production and trade of food and animals, such trend is considered the result of growing industrialization, as well as intensive production and breeding of animals and plants that catalyse the spread of pathogens (Smith and Bradley 2003). Potential health problems associated with food production are spread by increasing the capacity and intensification of agricultural production. The spread of zoonotic microorganisms throughout food is contributed by modern logistics and facilitation of food transport to consumers, changes in eating habits such as consumption of raw and exotic food, and increased consumption of high protein foods (Altekruse and Swerdlow 1996; Broglia and Capel 2012; Poljak et al., 2014). Moreover, due to the improvement of living conditions, as well as the development of medicine, there are many more elderly and immunocompromised people in the world who are particularly vulnerable to food infection. Climate changes that bring new vectors in areas where weather conditions do not sustain survival also contribute to this fact.

Although food has long been known as a source of zoonosis, this is forgotten in case of certain diseases, so it is sometimes necessary to remind us that man was the primary source of infection. One of such diseases is infection with *Helicobacter pylori,* whose discovery was awarded by the Nobel Prize in 2005. The fact that man was primarily infected with the bacteria from the milk of sheep is not known enough (Dore et al., 2001). Not only food, but also the environment where the food is produced is the source of infection. In 1981 Walton and White described the 100 zoonotic pathogens whose source is manure from farm animals.

List of zoonotic pathogens transmitted by food (year 1855) included a parasite *(Trichinella)*, but later more types of bacteria were added to the list, initially *Salmonella, Shi-*

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gella, Staphylococci, Clostridia and Bacillus cereus, followed by the discovery of the role of rotavirus and norovirus, and finally after the year 1990, *Campylobacter*, Yersinia, *Listeria*, E. coli and Cryptosporidium infection and Cyclosporine were added to the list. It is certain that in the 21st century new pathogens are going to be discovered so the most important world organization which monitors the incidence of such diseases (WHO/FAO/OIE) published that it expects an increase in the share of viral zoonosis, despite the fact that many microbiologists believe that viral diseases are species-specific (Clough, 2004).

There are certain doubts regarding the source of certain epidemics. An increased number of sources of zoonosis is not only a result of the increased movement of people and transport of exotic animals, but also a result of the transport of many autochthone types of food. In the last 30 years nearly half of known so-called "foodborne" pathogens were detected, to what the increased consumption of meat and meat products in particular had contributed (Tauxe, 2002). In order to prevent the possibility of human diseases after consumption of food as much as possible it is necessary to take sustainable approach to agriculture under the new slogan "One health". In order to understand some of the risks associated with increased production system in the field of food and to reduce the risk of emergence of infectious diseases, it is necessary to constantly monitor the progress of diseases. The base of each approach in the prevention and control of the occurrence of zoonosis is their recording. However, to improve methods of rapid detection of microorganisms and to explore methods of adaptation and survival of microorganisms in new conditions, a better understanding of bacterial resistance to drugs and the exploration of new methods of handling, storage and distribution of food are necessary. For this reason, institutions such as the OIE, WHO or EFSA, and terrestrial offices that record the occurrence of zoonosis have been established in order to ascertain the connection of their occurrence in animals and humans in many countries. This greatly contributes to the prevention of zoonosis, generally improves the health of people and animals and prevents instances of enormous economic and other damages.

The most important bacterial pathogens of foodborne infections and intoxications, and their incidence

From the 90s of the last century until today, four most important bacterial genus that cause foodborne diseases, namely *Salmonella, Campylobacter, Listeria and Escherichia coli* were identified. EFSA reports (2012 and 2013) on foodborne outbreaks of zoonosis. Epidemics recorded in the EU in 2010 and 2011 show that campylobacteriosis is on the increase and that this trend was repeated for the sixth year. The findings of *Campylobacter spp.* were again the most common in chicken meat. In the EU, the number of reported cases of salmonella infections has been continuing to decrease in a statistically significant way since 2006. This is due to the application of the new program for control of salmonella in breeding poultry that was implemented at the level of EU Member States. The bacteria are now mostly being determined in meat and meat products, poultry, and in few cases in eggs and egg products (EFSA, 2013). Also, the report states that the incidence of cases of human listeriosis was unchanged from the previous year. In comparison with previous years there was an increase in the number of human diseases caused by verotoxigenic *Escherichia coli* (VTEC), and most of the cases were caused by serogroup O157. Such bacteria are most commonly isolated from cattle and beef.

About 95% of cases of human salmonellosis in Europe and the United States were associated with the consumption of contaminated food, usually chicken meat, pork and beef, as well as eggs and egg products (Foley et al., 2008; EFSA, 2010). Data show that in 2013 the campylobacteriosis was the most common zoonosis reported in the EU (EFSA, 2015). Human campylobacteriosis after several years of rising trend finally showed stability. Findings of *Campylobacter spp.* are still the most common in chicken meat. According to the same report (EFSA, 2015) in most EU countries, human salmonellosis showed, as in previous years, the trend of decline in the number of its findings in fresh chicken meat, as well. "Ready-to-eat" food is still associated with listeria findings. In 2013, the number of confirmed human infections caused by verotoxogenic *E. coli* (VTEC) increased and no bacteria were found in food or animals (EFSA, 2015). In total, 5,196 outbreaks related to food and / or water were reported, and the most numerous were those caused by salmonella, then viruses, bacterial toxins and *Campylobacter spp.*, while in 28.9% of all outbreaks the cause remains unknown.

Literature describes well-documented listeriosis outbreaks that are often associated with the consumption of food, mostly milk and dairy products, meat and meat products, fresh vegetables and seafood. L. monocytogenes can accordingly be isolated from unpasteurized milk (D'Agostino et al., 2006) or various types of cheese (Kozačinski and Hadžiosmanović, 2001a; Makino et al., 2001) where the number of bacteria can reach up to 107 CFU / g. Studies showed that 30% of samples of raw meat (beef, pork, lamb and chicken) (Capita et al., 2001; Kanuganti et al., 2002; Rodriguez et al., 2004; Zivkovic et al., 1998) and 23% to 60% samples of poultry meat contain *L. monocytogenes* (Kosek-Paszkowski et al., 2005). The contamination of finished products is the result of contamination in the production plant or unhygienic conditions present during production (Laer et al. 2009; Thevenot et al. 2001) and due contaminants can be isolated from production plant working surfaces (Gudbjornsdottir et al. 2004; Holan et al. 2004; Koutsoumanis et al. 2004; Lebert et al. 2007; Gounadaki et al. 2008).

L. monocytogenes was found in fresh vegetables. The main reason for diseases in humans is considered to be an increase in the contamination of fresh vegetables in "fast-food" restaurants (Berrada, 2006; Gombas et al., 2003; Little et al. 2007). It was also isolated from fishery products in the amount of up to 27% (Gudbjornsdottir et al. 2004). Some authors consider its findings the source of contamination in fish processing industry (Huss et al., 2000; Tham et al. 2002).

Temperature is one of the most important factors that influence the growth of *L. monocytogenes* in food. A precondition for effective risk assessment of *L. monocytogenes* in "ready-to-eat" food is therefore to have accurate data on temperature conditions in food chain. It is well known that first steps in chain (e.g. production and distribution) are in many cases not controlled sufficiently (Afchain et al. 2005). Showcases, particularly refrigerators in households, are not controlled at all. Temperature control during transportation, storage and retail is usually in the responsibility of the seller and not under the direct control of the producer, while in households it depends on the assessment of the need for this kind of control by consumer himself (EFSA, 2007).

It is known that *C. jejuni* species are widespread in the environment. The way of their transfer has not yet been completely clarified. Such ubiquity nature of these bacteria contributes to their ability to quickly adapt to different environmental conditions, thanks to the hypervariability of their genetic material (Miller and Mandrell, 2005).

Given the fact that bacteria *C. jejuni* inhabit the intestinal tract of domestic and wild animals, the consumption of contaminated meat is considered to be one of the most important ways to infect humans, and the consumption of poultry meat is considered particularly risky (Habib et al., 2008 .; Wilson et al., 2009; Forbes et al., 2009). The presence of Campylobacter in poultry has been known for at least the past 30 years (Miller and Mandrell, 2005). The horizontal transmission due to contaminated food and water occurs very quickly among other members of the flock, and it has been found that the contamination spreads from infected birds to other animals within three days. Likewise, if poultry drinks contaminated water, most birds will be infected within seven days and rapid transfer between individuals will happen due to the fact that infectious dose for poultry amounts to barely 35 cells (Miller and Mandrell, 2005).

Despite assumptions on ways the colonization of poultry by Campylobacter occurs, the exact route of transmission between poultry itself has not yet been determined. However, the coprofagic behaviour of individuals is of importance (Gormley et al., 2008). It was also found that a flock can be simultaneously infected by Campylobacter strains with different genotypes, what is not surprising considering the very real possibility of contamination during slaughter and processing of meat (Forbes et al., 2009).

Research has also shown that in the United States as many as 20 to 100% of chicken parts are contaminated by *C. jejuni*, and according to the results of the US Food Agency, the percentage of quick-frozen poultry carcasses is 88.2% (Davis and Corner, 2007). In Belgium, it was found that 50% of chicken meat tested positive for Campylobacter, in the UK up to 80% but the percentage varied considerably depending on the type of meat (Habib et al., 2008). In addition, it was found that nearly 1.5 times more Campylobacter was present in chicken parts (breasts, drumsticks and wings) than in ground meat. Kovačić et al. (2013) detected *C. jejuni* in swabs of 84 chicken (14.6%) and 9 turkey samples (3.5%), out of 834 samples of poultry in total.

During food handling, despite all precautions, the most common cause of food poisoning today is salmonella (Forshel and Wierup, 2006). The symptoms of salmonellas are nausea, vomiting, abdominal pain, headache or diarrhea. They most commonly occur within 24 hours and last for 2-3 days, but usually pass without complications. Salmonella can be present in a healthy carrier (carriers), what also poses a danger for the spread of the disease (Johnson et al., 2005).

The primary reservoir of Salmonella is the intestinal tract of humans and animals, particularly poultry and pigs (Jorgensen et al., 2002; Ribeiro et al., 2002; Ozbey and Ertas, 2006). It is transferred by insects or other animals from faeces into the environment, water and soil (Hoorfar and Mortensen, 2000; Korsak et al., 2004; Malorny and Hoorfar, 2005). Eggs, poultry or raw poultry, and pig meat are the main carriers of salmonella infections for humans (Pangloli et al., 2003; Seo et al., 2004; Malorny et al., 2007). Botteldoorn et al. (2003) indicate an increase in the prevalence of Salmonella spp. in pig slaughterhouses and production environments where a high degree of contamination of carcasses after slaughter contaminated the environment of manufacturing plant and vice versa, notwithstanding the fact that the hygiene of due slaughterhouse is a critical factor in the case of contamination of meat. Based on the increased number of Salmonella isolates from animal feed, animal feed is considered a possible source of infection with salmonella in meat industry (Reiji and Aantrekker, 2004). Also, the rise of prevalence of salmonella in fresh fruits and vegetables (Liming and Bhagwat, 2004; Lin et al., 2004; Chang and Fang, 2007), as well as in fish and fish products was detected (Ponce et al., 2008).The infectious dose of salmonella is not defined, but according to certain data, 100 cells / 100 g of food can cause the disease in humans. The risk of infection depends on age, condition of the host and differences of bacterial serotypes within the genus. European legislation for the purpose of better protection of the population prescribed the amount of less than one (<1) bacteria in 25 g of food. As this number is the lowest limit of detection, this, in practice, implies the absence of that microorganism.

The role of World Health Organization (WHO)

The World Health Organization (WHO) is the umbrella organization for health with the fundamental principle of mandate being to collect data on health at the global level, to assess health trends and to provide technical assistance for the establishment of standards and norms in Member States.

According to the WHO data (WHO, 2004), on a global level, only from diarrhoea about 2.2 million people die annually, while the real cause is not yet defined. WHO is aware of the fact that foodborne diseases manifest in exactly this type of symptoms.

Food that is unsafe for human consumption and causes the disease, in some instances with fatal end, represents a permanent threat to the safety of public health and socio-economic development throughout the world. An entire range of burdens that represent expenses caused by foodborne diseases associated with pathogenic bacteria, viruses, parasites or food contaminated by chemicals is still unknown but it is considered very important. That is why the WHO, as a response to worldwide growing trend on informing on human health and in order to obtain data that previously did not exist but are associated with a particular type of disease, started an initiative to estimate the global burden caused by foodborne diseases (Kuchenmüller et al., 2009).

Notification system for cases of hygienically unsafe food present on the market (RASFF)

The Rapid Alert System for Food and Feed (RASFF) is primarily a tool for the exchange of information between competent authorities on food and feed consignments in cases where risks to human health are identified and cases when competent authorities need to take certain measures (RASFF, 2012).

The RASFF system was established in 1979 by the European Union to ensure the safety of food and feed, including the protection of human health. The exchange of information through the RASFF system helps Member States to act quickly and to coordinate in a response to health threats that originated from food or feed. The efficiency of the RASFF system is achieved through its simple structure. It consists of clearly established contact points both within the European Commission and at the national level of Member States (national contact point), established to exchange information in a clear and structured way.

The RASFF system network includes EU Member States, the European Commission, EFSA, ESA (the supervisory authority of the European Free Trade Association), Switzerland, Norway, Liechtenstein and Iceland; and the system is operated by the European Commission.

In order to communicate accurately and fast, and in order to avoid any mistakes in the exchange of information, there is only one designated contact point for each member of the RASFF system that represents the member of the system. In the Republic of Croatia the national RASFF contact point is the Veterinary and Food Safety Directorate at the Ministry of Agriculture.

The RASFF system provides the information on identified risks, noncompliant products, traceability and taken measures regarding food and feed, including food contact materials that are placed on the market of the country that issued the notification or materials that are retained at the point of entry into the EU, namely the border with neighbouring countries of the EU.

According to the seriousness of indentified risks and the distribution of products on the market, the RASFF notification is classified as "Alert notification", "Information notification" or "Border rejection notification" (RASFF, 2012; Babić and Đugum 2014).

Before sending the RASFF notification, the competent authority has already implemented many activities. Persons authorized for the implementation of official controls for food or feed have already conducted inspections of products placed on the market or being held on the border. It is possible that sampling was carried out and that due laboratory analysis results determined that certain product does not meet the prescribed requirements. The competent authority decides whether the problem falls within the scope of the RASFF system and notifies national RASFF contact point. National Contact Point prepares the RASFF notification and forwards it to the European Commission.

The European Commission and the RASFF system cooperate with the Rapid Alert System of the World Health Organization called the International Food Safety Authorities Network (INFOSAN). This network comprises contacts or national focal points in more than 160 member countries that receive information from the WHO in the form of INFOSAN notes about food safety issues and distribute such information to all relevant ministries in certain country.

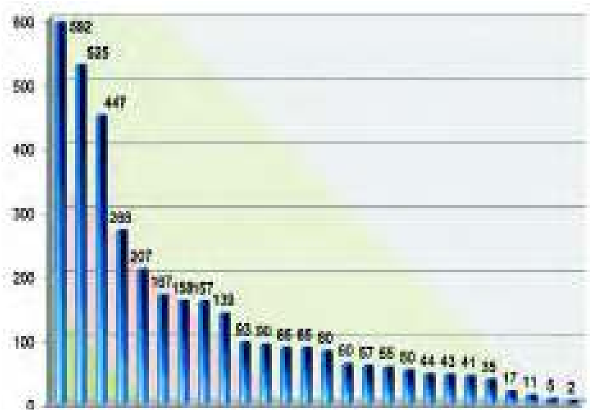

Figure 1. RASFF notifications by hazard category in 2012

- pathogenic microorganisms
- mycotoxins
- pesticide residues
- heavy metals
- composition
- migration
- foreign bodies
- poor of insufficient controls
- food additives and flavourings
- non-pathogenic microorganisms
- GMO/Novel food
- adulteration/fraud
- allergens
- organoleptic aspects
- VMP residues
- industrial contaminants
- parasitic infestation
- radiation
- labelling
- biocontaminants
- feed additives
- packaging
- biotoxins
- non determined/other
- BSE
- chemical contamination

Source: RASFF Annual Report 2012

Croatian (HR) RASFF in 2013

Croatia became a member of the RASFF network system with limited access to information in 2009 and after succession to the European Union on July 1 2013 became a full member holding all rights and obligations in accordance with the European legislation.

During 2013, the HR RASFF received a total of 40 notifications on the registration of incident or potential incident, six of which were rejected, while 34 notifications were processed and categorized. With regard to the classification of 34 notifications received by the HR RASFF, 25 were processed as Alert notification, four as Information notification and five as Border rejection notification, of which the Republic of Croatia sent eight notifications (three Information notifications and five Border rejection notifications) to the EU RASFF system.

In relation to the category of notified products, most of the notifications in the national rapid alert system were related to milk and milk products (47% or 16 notifications of a total of 34 notifications). Figure 2 shows the share of each category of products in relation to the classification of information in the national system.

With regard to the nature of risk, the largest share of notifications of a total of 34 analysed hazards referred to mycotoxins in food, namely 55.8%, of which over half of notifications (63%) were related to the occurrence of mycotoxins (aflatoxin) in milk and milk products.

Potentially pathogenic microorganisms were represented with a share of 8.8% of the total number of hazards reported during 2013 in the Croatian RASFF system.

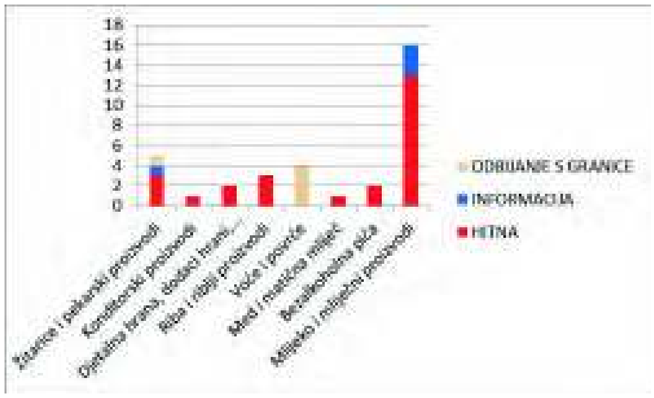

Figure 2. Share of category of products in relation to the classification of information in the national system

Source: Veterinary and Food Safety Directorate, 2014

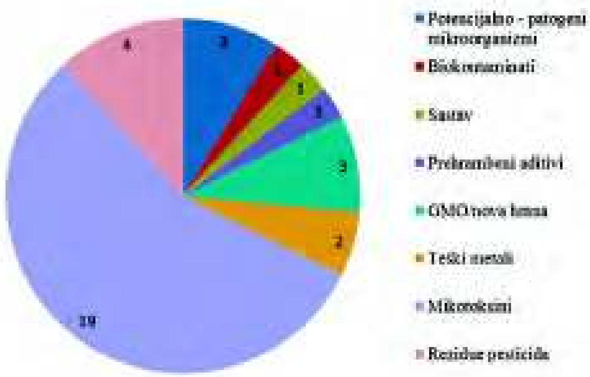

Figure 3. Nature of risk notified through Croatian RASFF system

Source: Veterinary and Food Safety Directorate, 2014

CONCLUSION

Food safety is the responsibility of producers and distributors. They are required to produce hygienically safe food in hygienic conditions while maintaining both high standard of animal health and welfare, and the use of safe production methods, in order to preserve the environment. As a priority, food business operators are required to apply self-control systems based on HACCP principles in all stages of production, processing and distribution of food. Aware of the fact that the consequences of the withdrawal of food from the market have a significant economic impact on the development of their production, food producers have or should have a huge interest in the reduction of pathogens transmitted by food, not only for the protection of human health, but because of the fact that by doing so they can reduce financial costs that these pathogens can cause.

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Accepted: 14 April 2015 **Delivered: 11 June 2015.**

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b) Proceedings:
Guerra, M., F. Bernardo (1997): Occurrence of Listeria spp. in traditional cheeses from Alentejo, Portugal. World Congress of Food Hygiene. The Hague, The Netherlands, 1997 August 24-29. Proceedings, p.214.

c) Book of abstracts:
Hadžiosmanović, M., L. Kozačinski, Ž. Cvrtila (2002): Shelf life of fresh poultry meat. Technology - food - nutrition - health, CEFOOD Congress, Ljubljana, September 22-25, 2002. Book of Abstracts, p. 99.

d) Book:
Gracey, J., D. S. Collins, R. J. Huey (1999): Meat hygiene. Tenth edition. W. B. Saunders company Ltd London, Edinburg, New York, Philadelphia, Sydney, Toronto.

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