Food safety depending on the conditions of transport and storage

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Conference paper

SUMMARY

Transportation and storage are practices that affect food safety. Temperature conditions that prevent the growth of potentially present pathogenic and spoilage bacteria must be maintained during storage and transport. The outcome of meat cooling is closely linked to the initial number of microorganisms and conditions during its transport and storage, which in turn depend on the relationship between time and temperature. Since spoilage bacteria grow faster than the pathogenic, the possibility to apply different combinations of temperature and time in meat transport is reduced. In order to meet the conditions prescribed by procedures for food trade and declared shelf life of meat during storage, the emphasis remains on the implementation of prerequisite programmes and the system of self-control in primary production, as well as the meat processing industry.

Key words: *food safety, transport, microbiological contamination*

INTRODUCTION

The globalization of markets has imposed new conditions for production and sales on producers in food trade. Such mass production focuses on the delivery of food in shorter time periods, while meeting the demands of consumers who have gradually changed their attitudes towards the notion of safe food. A large proportion of food products, particularly those of animal origin, is not only temperature sensitive, but requires a certain temperature regime from production to sales. It is therefore necessary to pay special attention to this type of products in order to preserve their safety and quality, i.e. to keep the food on the market safe (Hadžiosmanović et al., 2004).

Food safety has over time developed into a scientific discipline concerned with the handling, preparation and storage of foodstuffs aimed at preventing the incidence of foodborne diseases. Every scientific opinion on food safety adopted by competent administrative bodies and agencies will therefore remain under the scrutiny of both producers and consumers. At the same time, the emphasis remains on producers, representing subjects involved in the production of food, who are required to market only quality food that is confirmed as safe for consumption by the legislator (Anon., 2004; 2004a; 2004b; 2013; Knežević et al., 2013). Since all these attributes are regulated in relevant legislation, professional circles take part in the discussion about the impact of food safety regulations on business and challenges that their implementation presents to different countries and sectors (Havinga, 2008; Karlsen i Olsen, 2011; Mensah-Julien, 2011).

Risks and hazards

Foodborne diseases and transmission of pathogens to humans are still largely unknown. Data used to predict trends in the incidence and severity of foodborne diseases often refer to only a few developed countries and several pathogens. Nevertheless, an often suggested declining trend in diseases resulting from contaminated food and water that cause diarrhoea is primarily based on the premise of improving the production of microbiologically safe food, as well as conditions of transport and retail conditions in particular, especially in developing countries striving to secure their place on the global market (Newell et al., 2010). Considering the risk implied

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by foodborne diseases, Centres for Disease Control systematically monitor the incidence of certain pathogens. Their reports from various countries list the same disease-causing noxae upon eating different types of food. These continue to include *Salmonella* spp., *Campylobacter* spp., *Listeria monocytogenes*, verotoxigenic *Escherichia coli* (VTEC) and *Yersinia enterocolitica* (Njari et al., 2012). Furthermore, these bacteria also represent relevant microbiological pathogens in the assessment of the effects of carcass chilling regime, primarily cattle, pigs, lambs and poultry, and play a role as a potential threat to public health.

Meat inspection and food safety

Meat inspection is an important preventive measure in the production of meat. The post mortem inspection is of immense significance because during this stage pathological changes that indicate the presence of certain disease are usually observed (Newell et al., 2010). However, the number of infectious diseases of animals has been radically reduced in the majority of developed countries. Nonetheless, the number of farm animals that show no clinical or pathological signs of disease even though they carry zoonotic pathogens is on the rise. Animals that either develop no symptoms or display atypicality are thus regarded as asymptomatic carriers of zoonotic pathogens (*Salmonella* spp., *Campylobacter* spp., *L. monocytogenes*, *E. coli* O157) that represent a major risk to the human health. It goes without saying that it is impossible to detect these microbiological hazards during the inspection of slaughter line. The spread of microorganisms by cutting into the lymph nodes during the inspection of meat and organs is ever more evident. These are the very reasons why meat inspection protocols have been contested throughout the last decade. Even though early and subclinical cases are unlikely to be discovered during the inspection of slaughter line, an inspection of slaughter line may draw attention to the incidence of animal diseases, which has to be reported to veterinarians and farmers. This is the very reason why methods of inspection were revised and adapted to the severity and frequency of pathogens in certain animal species. The procedures of meat inspection may be modified to suit different forms of animal keeping or the age of animals. Hence, a great attention is given to ante mortem inspection, which remains important to establish the traceability and monitoring of animal welfare requirements. When the condition of animal health is not in question, due inspection relies solely on visual examination. Nevertheless, alternative methods of inspection may be used on the condition that they provide at least the same level of safety as the existing traditional methods (Stark et al., 2014).

Cooling and transport of meat

The inspection of meat and organs is followed by the phase of carcass chilling, i.e. the chiling of animal halves. The maximum temperature of entrails and innards cannot exceed 3 °C while the temperature of other meats cannot exceed 7 °C. All requirements associated with such procedures must comply with the applicable provisions of the legislation (Regulation 853/2004). These provisions do not specify the time required to lower the temperature of meat. The reasoning behind the chosen criterion of maximum temperature in the amount of 7°C remains unclear and is therefore cited as questionable in relevant scientific publications. Namely, it is known that pathogens such as *L. monocytogenes* and *Y. enterocolitica* grow and *Salmonella* spp. may show a modest growth at this temperature (James and James, 2014; Padmanabha et al., 2011; Prendergast et al., 2007; Elmnasser et al., 2006; Cole et al., 1990) even though the shelf life of meat complies with the relevant legislation. Maintaining the cold chain during the storage and transport of meat stands out as one of the measures introduced to reduce the public health risk. However, the impact of spoilage bacteria on meat shelf life must not be diminished. The upper level that indicates the spoilage of meat is considered reached when such bacterial population grows to 10^7 CFU/cm^2. An estimated time that *Pseudomonas*, as representatives of spoilage bacteria, need to reach 107 CFU/cm^2 on carcasses depends on the chilling process, the initial number of bacteria, the surface temperature of carcass during cooling in slaughterhouse and the temperature during transport. Models developed to predict the growth of spoilage bacteria indicate that *Pseudomonas* need approximately 2.3 days to reach 107 CFU/cm^2 in red meat and 1.1 day in poultry stored at 7 °C when there was a large initial number of bacteria (5 log_{10} CFU/cm^2) (Anon., 2016). Moreover, only the temperature of carcasses, i.e. halves, can serve as an appropriate indicator of bacterial growth because bacterial contamination usually occurs on the surface of carcasses (Buncic, 2006; Anon., 2014).

The same Regulation (853/2004) defines minced meat as boned meat that has been minced into fragments and contains less than 1 % salt, and prescribes the requirements that raw materials used for its production must satisfy, as well as the requirements that apply to the production of meat preparations and mechanically separated meat. It also determines that minced meat prepared from chilled meat must be prepared within no more than three days from the slaughter in the case of poultry, within no more than six days from the slaughter in the case of animal other than poultry and within no more than 15 days from the slaughter of the animals in the case of boned, vacuum-packed beef and veal. Immediately after production, minced meat and meat preparations must be wrapped or packaged and then chilled to an internal temperature of not more than 2 °C for minced meat and 4 °C for meat preparations or frozen to an internal temperature of not more than -18 °C. These temperature conditions must be maintained during storage and transport. Temperature therefore plays a key role in the production of minced meat. However, if the temperature is not maintained under the maximum allowed in the stages of production from chilling to mincing of meat, it can stimulate the growth of spoilage bacteria and other aforementioned pathogenic bacteria.

The majority of microorganisms that cause food poisoning cannot multiply at a temperature below 5 °C. This means that the temperature in each part of the cold chain should not drop below 5 °C and never exceed 8 °C. Even though the temperature in cold chain does not kill microorganisms, it prevents their multiplication in foodstuffs. There are two factors that are crucial for maintaining the quality and safety of products in cold chain: temperature and time period. Predictive modelling used to assess the impact of time and temperature on the growth of pathogenic bacteria during meat storage may help us to better understand the requirements prescribed by due regulations. As modelling takes into account the pH and water activity favourable for the growth of bacteria, but disregards microbial competition and lag phase, the provided time periods are based on the worst case scenario. Such analysis indicates that meat can be stored at a temperature of 2 °C for a period of 14 days in the case of red meat, 39 days in the case of vacuum-packed beef and only 5 days in the case of poultry, as well as that during these time periods an increase in the number of pathogenic bacteria is not greater than the increase prescribed by the applicable regulations. Alternative combinations of temperature and time during the storage of fresh meat from slaughter to mincing therefore are possible, whereas different storage temperatures affect the maximum storage time of fresh meat intended for the production of minced meat. Predictive modelling is in this respect used to identify various combinations of temperature and time that will sustain the growth of *Salmonella* spp., VTEC, *L. monocytogenes* and *Y. enterocolitica* in carcasses during storage even when all the requirements laid down in the Regulation 853/2004 are satisfied (Anon., 2014, 2014a).

However, the meat industry is facing the requirements that are not compatible with the prescribed limitations regarding temperature conditions and requirements related to the transportation and maximum time of storage of certain products, primarily minced meat and vacuum-packed beef and veal. This also applies to the transport of carcasses before the meat reaches the temperature of 7 °C, and the maturation of meat that can be extended up to 21 days to help improve its texture and flavour. This creates a conflict with the provision according to which the meat must be used for the production of meat products within not more than 15 days from the slaughter of the animals. The question of whether there is a way to interpret and adapt regulations to commercial requirements more liberally, especially when such changes do not impact the occurrence of public health risks, remains unanswered. The EFSA has for this precise reason adopted an opinion concerning the effect of different combinations of temperature and time during cooling in production facilities and transport on the growth of various pathogens in pork, beef and lamb, and made the comparison of such combinations with cold regime and requirements prescribed by current regulations (Anon., 2014). In addition, similar requirements prompted the adoption of the scientific opinion concerning the impact of time and temperature on the growth of bacteria that cause spoilage in fresh beef, pork and lamb, as well as poultry (Anon., 2016). Respective predictive model compared the growth of spoilage bacteria to the growth of bacteria that cause diseases (pathogenic bacteria). Spoilage bacteria grow faster than *L. monocytogenes* and *Y. enterocolitica* and therefore reduce the possibility to apply due combination of the target surface temperature of carcass, and the temperature and time of transportation, in practice. Even though cooling profiles that take into account the time and temperature may be used to achieve the same or slower growth of spoilage bacteria, they are restricted by the initial number of bacteria. Depending on the contamination of animals and hygienic conditions during the production, the initial level of carcass contamination with spoilage bacteria varies significantly. Slaughterhouses can significantly reduce such bacterial contamination by implementing applicable prerequisite programmes (good manufacturing and hygienic practices). This allows them to transport carcasses and halves over a longer period of time at a particular temperature. By contrast, a lack of hygienic control usually leads to an increase in the number of spoilage bacteria, which in turn reduces the time allowed for transportation. Subjects participating in food trade must be fully informed about the importance of the implementation of good manufacturing and hygienic practices in slaughterhouses and cutting plants, as well as the likelihood of carcass contamination. We must reiterate that the lower initial bacterial contamination allows for more flexible combinations of time and temperature that can be applied to cold storage, slaughterhouses and transportation of carcasses, halves or basic meat cuts (Anon., 2016) without compromising their safety.

CONCLUSION

Food safety begins in primary production. Should food be contaminated at this stage, it is difficult to avoid contamination in other production phases. The implementation of good manufacturing and hygienic practices during production allows safe transport and storage of foodstuffs and reduces the consequent danger to human health. Although applicable regulations determine the time and temperature of meat storage, depending on the initial contamination with pathogenic and spoilage bacteria, food safety may be compromised even when subject to proper cooling, transport and storage regime. Regardless of inspection, control and supervision during slaughter and meat processing, as well as the use of correct procedural criteria in each phase of production, food safety begins on the farm, with a healthy animal.

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