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Meat safety in the climate change context

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Abstract

Climate change is a global phenomenon in the 21st century which may have impact on the occurrence of meatborne hazards at multiple points in the meat chain continuum, from the primary production through to consumption. The assurance of meat safety is a complex task, which requires strong inter-sectoral cooperation between relevant stakeholders such as Competent Authority, Academia, Food Industry and Consumers. The emerging food safety risks due to climate change may pose a serious challenge to the meat safety control system. Therefore, a better understanding of anticipated changes would be of the utmost importance for governments to ensure preparedness.

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1. Introduction

Climate change is a global phenomenon in the 21st century which may have both direct and indirect impact on the occurrence of meatborne hazards at multiple points in the meat chain continuum, from the primary production through to consumption[1]. Assuring the meat safety is a complex task, which requires an active involvement of the major stakeholders: Competent Authorities, Academia, Food Industry and Consumers. The modern, risk-based meat safety management system relies upon integrated, synergistic and coordinated controls at major stages/modules

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along the meat chain, `from farm-to-fork` (Table 1). However, emerging food (meat) safety risks due to climate change may still pose a serious challenge to the meat safety control system, in terms of industry food safety management programmes, public sector food safety activities (environmental/veterinary/food/health authorities) and risk assessors.

Table 1. A `modern` - integrated meat safety management system.

Meat chain – modules	Risk management
	Animal welfare
	Animal Health Status/Heard Health Surveillance Programme (HHSP)
	Biosecurity
I On-farm	Feed
	Vaccination
	Waste management
	Pathogen-free farms
II Transportation	Animal welfare
Livestock market	Stress prevention
Collection centre	Prevention of cross-contamination between animals
Lairage	Logistic separation of animals from different farms
III Slaughter	Training
Meat processing	GHP/GMP
	SSOP
	HACCP
	Microbiological criteria (process hygiene and food safety)
IV Storage	Good Warehousing practice (GWP)
Distribution	Good Distribution Practice (GDP)
Retail	Good Retail Practice (GRP)
	Prevention of cross-contamination during handling
V Consumer	Proper cooking
	Prevention of post-cooking re-contamination

A better understanding of changes that might arise in the close future is an essential first step to ensuring preparedness for those changes. It would be, therefore, of utmost importance for governments to be prepared for those anticipated events.

2. Meatborne disease agents

Evidence of the impact of climate change on the transmission and incidence of foodborne diseases comes from a number of sources, e.g. seasonality of foodborne and diarrheal disease, changes in disease patterns that occur as a consequence of a temperature[2], and association between increased incidence of foodborne illness and severe weather events (e.g. floods, draughts, storms)[3,4]. Extreme climate events may alter the risk of pathogen infections and diseases in both animals and plants, modifying the host–pathogen dynamics in a wide range of species. Valuable information on complex interactions that occur between hosts (meat animals), pathogens, and the environment, is needed in order to pave the way for predictive models and ultimately, early and efficient response to disease threats[5]. For instance, the change of local climatic conditions may influence local vegetation and crop production which, in turn, may affect the quality/safety of animal feed and provoke changes in food (meat) animal epidemiology[6]. Furthermore, insects and other vectors may carry foodborne pathogens and enter new ecological zones. Therefore, farmers may need to adjust the timing of on-farm pest control as pest life cycles also respond to climate change.

The changes between hosts, pathogens, and the environment due to changed climatic conditions may result in increased susceptibility of animals and subsequent (intermittent) fecal shedding of meatborne pathogens (e.g. *Salmonella*, *Campylobacter*, pathogenic VTEC, *Yersinia*) which may cross-contaminate the hides/skins of animals, e.g. cattle, pigs (on-farm, during transport, in-lairage) and cross-contaminate the carcasses at slaughter-to-dressing[7]. The contaminated carcasses/meat may than pose a food safety risk to consumers, in particular to vulnerable groups, e.g. YOPI (young, old, pregnant, immunocompromised).

2.1. Sources and modes of transmission of meatborne pathogens

The microbiota of meat consists of microorganisms (including the pathogens) associated with the raw material, acquired during handling/processing and surviving the preservation and storage. The general scenarios by which meat become contaminated with pathogenic bacteria, viruses and parasites include: i) contact with human/animal sewage/feces; ii) contact with infected meat handlers, e.g. ubiquitous bacteria on the skin, nose and throat of healthy individuals; iii) environmental contamination (airborne, water, food contact surfaces), e.g. pathogens ubiquitous in nature. Such contamination may arise at any point along the meat chain continuum, `from farm to fork` (meat chain modules I-V, Table 1) and may originate from any number of sources.

3. The impact of climatic factors on meat safety

Weather, which is impacted by the climate, affects the timing and intensity of foodborne outbreaks[8]. The most important factors influencing the ecology of food(meat)borne pathogens are presented in Table 2.

Table 2. The general influence of climatic factors on food/meat safety.

Climatic factors	**Impact on food/meat safety**
Seasonality	Pathogens` survival (stress response)
(temperature, humidity)	Pathogen emergence (microbial evolution, gene transfer)
	Population susceptibility (YOPI)
Extreme weather events	Increased susceptibility of affected population (refugees in close quarters)
(flooding, drought, hurricanes)	Increased susceptibility of meat animals (ingestion of spores via water, soil and feed - *Cl. botulinum*)
	Changes in water availability
	Increased severity of disease

The elevated temperature may speed up the pathogen proliferation along the meat chain. For these reasons, animal health and interaction of meat animals with weather conditions should be monitored carefully, as this may be related with increased susceptibility of animals to zoonotic agents, including meatborne pathogens (Table 3)[1].

Table 3. Examples of some meatborne zoonotic agents that are expected to be affected by climate change and their mode of transmission.

Meatborne agents		
Bacterium	Host	Mode of transmission
Salmonella	Poultry and pigs	Faecal-oral
E. coli O157:H7	Cattle and small ruminants	Faecal-oral
Campylobacter	Poultry	Faecal-oral
Yersinia	Pigs – a major livestock reservoir; Birds and rodents	Handling pigs at slaughter is a risk to humans
Anaerobic spore forming Bacteria (e.g. *Clostridium*)	Birds, mammals and livestock	Ingestion of spores through environmental routes, water, soil and feeds

L. monocytogenes	Livestock	A seasonal occurrence in livestock associated with feeding of silage
Protozoan	Host	Mode of transmission
Toxoplasma gondii	Cats, pigs, sheep	Cat faeces are a major source of infection; handling and consuming raw meat from infected sheep and pigs pose a zoonotic risk
Cyptosporidium parvum *Giardia intestinalis*	Cattle, sheep	Faecal-oral transmission; oocysts are highly infectious and with high loadings, livestock faeces pose a risk to meat animal handlers
Parasite	Host	Mode of transmission
Tapeworm: *Cysticercus bovis* *Cysticercus cellulosae*	Cattle, pigs	Faecal-oral
Liver fluke: *Fasciola hepatica*	Sheep, cattle	Eggs are excreted in faeces, and life cycle involves snail hosts; human cases generally associated with the ingestion of marsh plants (e.g. watercress)

4. Conclusion

Pathogens rarely emerge without a reason. The emergence and/or re-emergence of zoonotic food(meat)borne pathogens usually occurs as a consequence of a combination of two or more specific factors. The major drivers for the pathogen emergence are associated with changes in the following sectors: (i) ecology and agriculture; (ii) technology and industry; (iii) globalization; (iv) human behaviour and demographics; (v) epidemiological surveillance; and (vi) microbial adaptation[9]. Further, emergence may not necessarily be predictable. For example, the climate-driven changes in the movement of animal and human populations may facilitate the spread of a pathogen which previously was of a low prevalence or little consequence.

Therefore, the early identification and prioritization of the climate-induced emerging biological risks and their interactions between meat animal, plant and public health must be better understood by the governments[10]. It will require a proactive approach and coordinated, inter-sectoral cooperation between environmental, veterinary, food and health authorities, to ensure preparedness for the anticipated changes.

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