
Biological meat safety: challenges today and the day after tomorrow

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Abstract

The paper overviews the present status and challenges, as well as new and emerging longer-term issues, in the area of biological meat safety. It includes outlines of both prioritization process for biological meatborne hazards and global strategies for control of the priority hazards. It is concluded that modern meat safety assurance is meat chain- and risk-based, whilst the monitoring system should enable warning about any new and emerging meat safety issues.

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Keywords: biological hazards; meat; zoonoses; pathogens; control

1. Main biological meatborne hazards - present status and challenges

1.1. Bacteria

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decontamination or freezing of carcasses.

*Salmonella* - In the EU in 2013, there were 82,694 reported and confirmed human cases (9 deaths; case fatality 0.14%), most commonly with *S. Enteritidis* and *S. Typhimurium* (39.5% and 20.2%, respectively). *Salmonella*-positives were most commonly fresh turkey meat (5.4%), followed by fresh broiler, pig and bovine meat. Some 0.2%, each, of the fattening turkey flocks and the broilers flocks were positive for these two target serovars. However, the BT-SAM model estimates that around 65% and 28% of the human cases are attributable to eggs and pigs, respectively. The main control measures for *Salmonella* in the meat chain are focused primarily on reducing the flock prevalence, but also improving process hygiene in abattoirs.

*Yersinia* - A total of 6,471 confirmed human cases of yersiniosis (two deaths; case fatality 0.05%) were reported in 2013 in the EU, predominantly *Yersinia enterocolitica* and strains of biotype 4 (serotype O:3) and biotype 2 (serotypes O:9). *Y. enterocolitica* findings were associated primarily with pig meat and products thereof. In pigs, *Y. enterocolitica* resides particularly in tonsils, and so head-to-carcass cross-contamination should be prevented in pig abattoirs. With regard to *Y. pseudotuberculosis*, serotype I is by far the most common serotype associated with human and animal infections (followed by serotype III); wild animals are probably the principal reservoir in Europe.

*Verocytotoxigenic Escherichia coli* (VTEC) - In 2013, 6,043 confirmed human cases (13 deaths; case fatality 0.36%) of VTEC infections were reported in the EU. The serogroups most commonly involved in human disease were O157, followed by O26. Serogroup O157 was primarily detected in ruminants (cattle, sheep and goats) and meat thereof; but O26, O87, O103 and O113 were also detected. The main focus of control measures for VTEC are prevention or reduction of contamination of meat at ruminant abattoirs; the effectiveness of on-farm controls for this pathogen is limited presently.

*Listeria monocytogenes* - In the EU in 2013, there were 1,763 confirmed human cases (191 deaths; case fatality 15.6%) of human listeriosis. Fish products (mainly smoked fish) were the most commonly contaminated retail foods, followed by soft and semi-soft cheeses, RTE meat products and hard cheeses. The main control measures for foodborne listeriosis are focused primarily on maintaining high standards of hygiene of food processing and related environment, and on suppression of the pathogen’s growth in processed foods including meats.

Antimicrobial resistance (AMR) - Of particular interest are ESBL, AmpC and MRSA. ESBL (extended-spectrum β-lactamasases) are plasmid-coded enzymes, found in *Enterobacteriaceae* and mediating resistance to different β-lactam antibiotics. AmpC (AmpC β-lactamases) are enzymes cephalosporinases, coding for which is on chromosomal DNA in many Gram-negative bacteria, mediating resistance to penicillins and 3rd/4th generation cephalosporins. Bacterial groups most commonly carrying those AMR genes are *Escherichia coli* and non-typhoid *Salmonella*; including those associated with poultry and meat thereof. Presently, comparative efficiency and prioritisation of control options to reduce public health risks caused by ESBL and/or AmpC-producing bacteria related to food-producing animals is still unclear. Nevertheless, a measure based on restricting or stopping all uses of systemically active 3rd/4th generation cephalosporins in food animals is considered as highly effective. MRSA (Methicillin resistant *Staphylococcus aureus*) is widespread in the EU as a hospital infection. CC398 is most common MRSA clone associated with asymptomatic carriers in meat animals (pigs, calves, poultry), and also abattoirs and raw meat, but no related meat/food-borne MRSA disease has been documented to date.

1.2. Parasites

*Trichinella* - In 2013, 217 confirmed trichinellosis cases (one death; case fatality 0.56%) in humans were reported in the EU. Domestic pigs and hunted wild boar had prevalences of 0.0002% and 0.1%, respectively (vast majority in Eastern Europe). The main *Trichinella* control measures include pig production under controlled conditions, testing of slaughtered pigs, or inactivation of the parasites in the meat (sufficient freezing, heat treatment). In endemic regions, education of farmers, hunters and consumers is also an important risk reduction measure.

*Toxoplasma gondii* – There are numerous routes of human infection with this parasite. In the EU, *Toxoplasma* was reported in pigs, cattle, sheep, goats, dogs, cats, wild boars, deer, water buffaloes, and some other wildlife animal species. Pigs, particularly outdoor raised pigs, and small ruminants are the most relevant animal species for meatborne toxoplasmosis. *Toxoplasma* prevalence in pigs varied between EU countries, from 0% to 25.8%. The main *Toxoplasma* control measures include either testing of slaughtered pigs/sheep/goats or inactivation of the
Among the foodborne viruses most important for public health, comprising Norovirus (NoV), Hepatitis A virus (HAV) and Hepatitis E virus (HEV), only HEV has been identified also as a zoonosis; it is associated primarily with pigs. The diagnosis of HEV infections in humans is not routinely conducted in most laboratories, and therefore, it is considerably under-diagnosed. The main control options focus on prevention of HEV contamination. Also, high risk groups (underlying liver disease, immuno-compromised, pregnant) should be advised against eating raw/undercooked meat and liver derived from wild boars and domestic pigs.

1.4. Prions

To date, among transmissible spongiform encephalopathies (TSEs) in animals (Classical BSE, Atypical BSE H-type and L-type, Classical scrapie, Atypical scrapie, Chronic Wasting Disease-CWD, Transmissible Mink Encephalopathy-TME), only the Classical BSE agent has been evidenced to cause TSE in humans (variant Creutzfeldt-Jakob Disease (vCJD). Although there is no epidemiological evidence that Classical scrapie is zoonotic, the zoonotic potential of Atypical scrapie agent needs further investigation. Nevertheless, transmission studies to human PrP transgenic mice or primates suggest that some TSE agents other than the Classical BSE agent in cattle (namely L-type Atypical BSE, Classical BSE in sheep, TME, CWD agents) might have zoonotic potential; and even indicate that the potential of the L-type Atypical BSE agent appears similar or even higher than that of the Classical BSE agent. With regard to present risk mitigation measures, the current policy of removal of Specified Risk Material (SRM) of slaughtered ruminants from the food chain enables around one logarithm reduction of the relative infectivity associated with the carcass of an infected animal. This policy, along with controls of ruminant feeds in respect to SRM, remains the main BSE/TSE control strategy.

2. Prioritization of and global control strategies for the main meatborne hazards

Table 1. High and medium priority biological meatborne hazards on/in raw (carcass) meat.

<table>
<thead>
<tr>
<th>Biological hazard</th>
<th>Bovines</th>
<th>Ovines/ Caprines</th>
<th>Porcines</th>
<th>Solipeds</th>
<th>Poultry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campylobacter spp. (thermophilic)</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Salmonella enterica</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Yersinia enterocolitica/ pseudotuberculosis</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Human pathogenic VTEC</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>ESBL/AmpC E. coli</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Toxoplasma gondii</td>
<td>Undetermined</td>
<td>High</td>
<td>Medium</td>
<td>Undetermined</td>
<td>Low</td>
</tr>
<tr>
<td>Trichinella</td>
<td>N/A</td>
<td>N/A</td>
<td>Medium</td>
<td>High</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Table 2. Principles of biological meatborne hazards risk-reduction strategies.

<table>
<thead>
<tr>
<th>Pre-harvest stage</th>
<th>Harvest stage</th>
<th>Post-harvest stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevention of introduction and/or spread of pathogens within the farm.</td>
<td>Prevention/reduction of cross-contamination via slaughtering process and abattoir environment.</td>
<td>Effective treatments of meat (e.g. cooking).</td>
</tr>
<tr>
<td>Prevention of ingestion of pathogens by animals.</td>
<td>Elimination from and/or suppression of Cold chain maintenance.</td>
<td>Prevention of cross-contamination from raw to ready-to-eat foods.</td>
</tr>
<tr>
<td>Suppression of ingested pathogens within</td>
<td>Adequate post-cooking handling.</td>
<td>Keeping food either chilled or hot (&gt;60°C).</td>
</tr>
</tbody>
</table>
animal GI tract. pathogens on final carcasses. Enhancement of animal host response. Prevention/reduction of contamination during meat boning and cutting.

**Education and training of all the participants and all the stages of the meat chain**

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Table 3. Global aims and philosophy of revised, modernised meat inspection.

<table>
<thead>
<tr>
<th>Public health impact increased</th>
<th>Meat chain- and risk-based</th>
<th>Comprehensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus on high priority/relevant hazards</td>
<td>Risk categorisation of both farms and abattoirs; balancing the two</td>
<td>Meat safety assurance, rather than just meat inspection</td>
</tr>
</tbody>
</table>

3. **Future global challenges in biological food/meat safety**

- **Climate change** - Epidemiology of food/meat-borne biological hazards can change, hence the food safety, through the effects of droughts, floods or increasing temperatures that could change.

- **Scarcity of water** – Patterns of introduction and/or environmental recycling of zoonotic agents can change due to the increasing scarcity of water (and its quality deterioration) for irrigation and processing and drinking.

- **Increase in food and energy prices** - Can lead to changes in diets, thus change patterns of human exposure to foodborne hazards. Large scale diversion of food, e.g. cereals, into biofuel production could increase the risk of hunger and malnutrition which would increase the population’s susceptibility to diseases.

- **Alternative food and feed sources** – Problems with food prices and/or food security in developed countries would stimulate the use of alternative foods/feeds, including importations from exotic regions, with yet unknown implications for the epidemiology of existing and/or newly introduced foodborne disease.

- **Emergence of pandemics** - The threat of global pandemics (e.g. avian influenza, Ebola) and the spread of vector borne diseases to new areas (e.g. blue tongue, Rift Valley fever, and West Nile fever) could be expected to further increase by globalization of both people movements and food/feed trade.

- **Demographic change** - Another emerging risk is an increasing proportion of highly susceptible people (YOPIs - young, old, pregnant and immunocompromised) which would change the dose-response for pathogens.

- **Bio- or agri-terrorism** - Intentional threats to the safety and security of the food chain is another aspect with increasing visibility; the preventative measures are highly complex and as yet unclear.

- **New technologies** - New animal production systems with increased outdoor access could reintroduce certain, currently controlled hazards. The changing surrounding environment and wildlife population could lead to introduction of new animal species or pathogens. Use of new processing methods and increase in mildly processed foods call for a reappraisal of their safety.

- **Changes in biological hazards** – All factors indicated above could induce new genotypic or phenotypic changes in biological hazards, with challenging implications for their modified or newly acquired ability to cross the species barrier, survival/growth patterns, pathogenicity and diagnostic difficulty; this is exacerbated by high strain diversity within hazard species.

4. **Further reading**


