The Food Research, Safety and Training Network (FRST-NET) initiative, step one: Issues relevant for meat safety assurance at abattoir level

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Abstract

Recent data from the European Union monitoring of zoonoses and zoonotic agents confirm that microbial contamination of meat, especially raw meat and fresh raw meat products, is one of the most relevant food safety issues. The most relevant foodborne pathogens (e.g. *Salmonella* spp., *Campylobacter jejuni/coli*, *Yersinia enterocolitica*, verocytotoxigenic *Escherichia coli*) can be harboured in the gastrointestinal tract of, and faecally shed by, healthy meat-producing animals. The most frequent chain of events leading to meatborne illness involves such microorganisms subsequently transferred to humans through production, handling and consumption of meat and meat products. Foodborne pathogens in meats and the products thereof have to be controlled through a continuous farm-to-fork system and should take into account not only the risks, but also technical possibilities, consumers' attitude and behaviours, and cost–benefit analysis. Whilst sufficient knowledge has accumulated identifying the main concept of, and approaches to, modern meat safety assurance at abattoir level, a number of knowledge gaps on some aspects and issues still exist. Therefore, in this paper, the main meat safety risk reduction options in general and more specifically at abattoir level are outlined. Furthermore, particular scientific interests and experiences of several central-European academic institutions, in the area of food hygiene/safety, are briefly outlined. Finally, a synergistic scientific collaborative network in the area of hygiene/safety of meat at abattoir (first step) and meat and other foods at other food chain stages (subsequent steps) has been initiated.

Food hygiene, food safety, foodborne pathogens, meat, abattoir

Introduction

The most recently published information on the occurrence of zoonoses and food-borne outbreaks in the European Union (EFSA 2012) indicated that bacterial foodborne diseases were the main food safety issue in 2010. Among these, campylobacteriosis was the most commonly reported zoonosis with 212064 human cases. *Campylobacter* was most often detected in fresh broiler meat. This was followed by 99020 reported salmonellosis cases in humans, although the decreasing trend in case numbers (already observed in previous reporting periods) continued in year 2010. *Salmonella* was most often detected in fresh broiler and turkey meat. The number of human listeriosis cases in 2010 year was 1601, mostly acquired from ready-to-eat foods. A total of 4000 confirmed verotoxigenic *Escherichia coli* (VTEC) infections were reported in year 2010, and an increasing trend has been observed since 2008. VTEC was also observed in food and animals. The numbers of human yersiniosis cases have been decreasing in recent years and 6776 cases were reported in 2010. *Yersinia enterocolitica* was isolated also from pig meat and pigs. When considering outbreak data for 2010, most of the 5262 reported food-borne outbreaks were caused by *Salmonella*, viruses, *Campylobacter* and bacterial toxins.

Although the main reported food sources of the EU outbreaks in 2010 were eggs, mixed or buffet meals and vegetables, the data on occurrence of the main bacterial foodborne

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pathogens in meat-producing animals and meats indicate that meat, especially raw meat and fresh raw meat products, is one of the most relevant food safety issues. The most relevant foodborne pathogens (e.g. *Salmonella*, *Campylobacter jejuni/coli*, *Yersinia enterocolitica*, VTEC) can be harboured in the gastrointestinal tract of food-producing animals, and the most frequent chain of events leading to meatborne illness involves these organisms subsequently transferred to humans through production, handling and consumption of meat and meat products. Foodborne pathogens in foods including meats have to be controlled through a continuous farm-to-fork system and should take into account not only the risks, but also technical possibilities, consumers' attitude and behaviours, and cost–benefit analysis (Noerrung and Buncic 2008). However, some aspects of the control system are pathogen-specific. Thus, some pathogens in meats, including those indicated above, are most efficiently controlled by the main interventions applied during primary production combined with optimization of the slaughter hygiene.

The main aims of this paper are: a) to briefly outline the main meat safety risk reduction strategies in general and more specifically at abattoir level; b) to indicate some knowledge gaps requiring further investigation so to improve meat safety assurance at abattoir level; and c) to identify particular scientific interests and experiences of several central-European academic institutions with the aim of forming a synergistic scientific collaborative network in the area of hygiene/safety of meat at abattoir (first step) and meat and other foods at other food chain stages (subsequent steps).

1. The need and tools for prioritization of biological meat safety hazards

Within the total foodborne disease burden, it is necessary to prioritize foodborne hazards, with the aim of directing the main efforts and resources towards control of those posing the highest public health relevance. Ideally, the prioritisation is based on risk ranking that can have various global scopes: *single hazard-single product*, or *single hazard-multiple products*, or *multiple hazards-single product*. Depending on the purpose and available time-, finance- and expertise-related resources available, either qualitative (faster, simpler, cheaper, but only descriptive) or quantitative approaches (slower, complex, expensive, but numerical) can be used.

Nine risk ranking tools developed by various institutions worldwide were recently reviewed by EFSA (2012a). They differ in their purpose, the degree of complexity, level of quantification, and approach to model construction. None of the available tools could be recommended to be used as a universal use risk ranking tool for biological hazards. However, some of the currently available tools can be further adjusted to answer specific risk ranking purposes and questions. A qualitative approach was recently used by EFSA for the purpose of pig (EFSA 2011) and poultry (EFSA 2012b) meat inspection and included: a) enlisting all hazards transmissible to humans *via* pork ingestion; and b) conducting qualitative risk ranking. Because the target of the hazard assessment/ranking was the final pork carcass at abattoir, neither hazards that may be present in pigs/pig carcasses but transmissible to humans primarily *via* routes other than foodborne (e.g. occupational risk), nor those requiring proliferation before causing disease were included in the analysis. The data analysed included prevalence on pig carcasses, incidence and severity of human disease and source attribution (% of the cases caused from pork). For source attribution, available data is scarce, so a combination of outbreak data, microbial subtyping, epidemiological studies and comparative exposure assessment was used, as well as structured expert opinion.

Depending on the purpose, the described principles of qualitative hazard prioritization may be used in a range of risk management decision making. However, prioritization always relates to the current situation: refinements reflecting differences between time periods, geographical regions or production systems are necessary if/where monitoring data so indicate. Hence, the analysis must be revisited regularly. In any case, for those hazards identified as of higher priority, appropriate and effective risk-reduction options and strategies have to be identified, optimized and implemented.

2. Biological meat safety risk reduction strategies

2.1 Global aspects

Biological risks may be controlled at a number of steps in the meat chain. These are strongly interconnected and can be grouped into three main stages: pre-harvest, harvest and post-harvest. Whilst the main principles for the biological meat safety risk management are universal, some of related details may be meat-chain-step-, country- and pathogen-specific (Noerrung and Buncic 2008).

During the *pre-harvest phase*, "recycling" of microbial hazards can be reduced through agricultural land- and animal by-products management e.g. controlled use of manure/slurry/abattoir wastes as fertilisers. The use of HACCP systems in feed production, including antimicrobial treatments (e.g. heating, pelleting, fermentation), can reduce exposure of the animals (e.g. pigs, poultry) to microbial pathogens (e.g. *Salmonella*). Introducing new animals only from known/controlled sources and biosecurity measures (vermin-, movement controls) can reduce the risks of introducing microbial pathogens to farms. Optimal animal welfare (stress management) and hygienic animal husbandry (including the all-in, all-out system) reduces the shedding and the spread of the hazards, respectively, within farms. In addition, microbial pathogens in the alimentary tract of animals can be suppressed using prebiotics, probiotics and/or competitive exclusion. A promising new intervention strategy could also be the use of specific bacteriophages, e.g. to reduce *Campylobacter* load in caecal contents and faeces of poultry. Furthermore, the resistance of animals to pathogens can be enhanced *via* vaccination (e.g. poultry against *Salmonella*).

During *harvest phase*, transport and lairaging (T-L) increases the occurrence and/or levels of microbial hazards (e.g. *Salmonella, Campylobacter* spp.or VTEC) in the animals. The main risk factors during T-L include mixing of unfamiliar animals, stress, extended T-L duration, and contamination of vehicles/pens. At abattoirs, the primary sources of microbial contamination are animals: the hair/skin/feathers, the alimentary tract (i.e. faeces), the nasopharyngeal cavities and the urogenital tract. To reduce contamination from incoming animals, the "logistic slaughter" approach is used: higher-risk batches of animals are slaughtered separately from lower-risk ones. The risk ranking is based on the Food Chain Information (FCI) concept, including consideration of data from on-farm monitoring and surveillance of zoonotic agents, farm quality assurance and herd health plans. Secondary sources of meat contamination include contaminated aerosols, surfaces, tools and meat handlers throughout the abattoir. Antimicrobial measures include sanitation and potential use of skin- and/or carcass-decontamination treatments. Overall, meat safety in abattoirs is managed through implementation of verified prerequisite programmes (Good Hygiene Practices; GHP) and HACCP plans.

During *post-harvest phase*, based on the microbial risks, processed meats can be grouped into products that receive a bactericidal step and those that do not. The latter can be further divided into those not allowing growth of pathogens and those allowing it. In no-bactericidal-step products, microbial controls rely on the "hurdle" concept. At retail level, all meats can be contaminated through further handling (e.g. slicing, packaging). At catering-consumer level, the microbial meat safety problems relate to final preparation of food for consumption. Overall, the risk reduction measures at post-harvest phase are managed through GHP-HACCP systems, and include effective cleaning-sanitation of all meat-related premises, uninterrupted cold chain, bactericidal steps wherever possible, prevention of cross-contamination during further handling and/or food preparation, post-cooking holding at > 60 °C or < 5 °C, and food hygiene education of consumers.

Globally, today, a longitudinal-integrated approach to meat safety assurance is widely adopted (Buncic 2006; FAO/WHO 2006), with the main responsibility for meat safety resting with producers. Governments have a more advisory and official control/auditory role. From the operational perspective, the meat safety assurance system comprises:

- *preliminary activities* including defining hazard-meat combinations of particular relevance (via epidemiological data, risk profiling) and traceability;
- *evaluation of risk management approaches* including identification of available (science) and selection of the "most appropriate" (decision making) control options;
- *implementation of control measures* including those "owned" by the producers (e.g. GHP/HACCP) and regulatory-mandated procedures and criteria, but implementation of all are subject to regulatory verification and auditing; and
- *follow-up and re-evaluation* including identifying new problems (monitoring), assessing the effectiveness of implemented controls (surveillance) and reviewing the whole system if the expected results are not achieved.

2.2 Abattoir level aspects

Today, the two main strategies/measures for control of public health hazards/risks in abattoirs are official meat inspection and process hygiene.The main biological hazards associated with meat at abattoir level are mainly zoonotic - originating from animals for slaughter - and can be divided into two groups: a) hazards that cause macroscopically detectable abnormalities/lesions in animals pre- and/or post-mortem ("visible hazards"); and b) hazards that do not cause macroscopically detectable abnormalities/lesions in slaughtered animals ("invisible hazards"); they may be present in the gastrointestinal tract and/or on the skin of clinically healthy animals and consequently contaminate carcass meat.

Hazards in the first group can be detected through macroscopic observation of related abnormalities/lesions by current official *ante-* and *post-mortem* meat inspection (Regulation EC No 854/2004); therefore, related risks are associated only with animals showing corresponding macroscopic abnormalities. Hazards from the second group can be excreted by any animal (with unrelated abnormalities or without any abnormality), so are associated with all animals and cannot be detected by current macroscopic meat inspection. The "invisible" group of hazards can be detected only through additional, laboratory testing of samples taken from carcasses/organs; however, such testing of samples from all carcasses on multiple hazards is not practical, nor does it provide guarantees for the absence of hazards from all parts of slaughtered animals (Buncic 2006). Additionally, microbiological tests do not deliver results within adequate timeframes. It has been recognized that the main control strategy (prevention or reduction) for these microbial hazards is based on optimizing the slaughter and carcasses dressing hygiene. In practice, this is achieved through the implementation of Good Manufacturing/Hygiene Practice (GMP/GHP) and Hazard Analysis and Critical Control Points (HACCP) plans at abattoirs.

The role of meat inspection at abattoirs

Current meat inspection still has significant value in detecting and controlling hazards, but primarily those related to animal welfare, animal health and meat quality. In respect to public health-relevant hazards, current meat inspection alone cannot protect public health from meatborne hazards sufficiently. It can detect only few zoonotic hazards transmissible to humans *via* meat consumption (e.g. *T. saginata/solium*, *Trichinella* spp.), but those occur only rarely in Europe. Other zoonotic hazards detectable at meat inspection are transmitted to humans primarily *via* routes other than eating meat, such as *Mycobacterium bovis*, *Brucella* spp., *Erysipelotrix rhusiopathiae*, *Leptospira*, and hence are hazards for occupational risk rather than meat safety (EFSA 2011). On the other hand, the main meat safety hazards presently causing the majority of human foodborne illness (e.g. enteric pathogens *Salmonella, Campylobacter, Yersinia*, VTEC), or causing serious concerns (e.g. protozoan parasite *Toxoplasma gondii*) do not cause any lesions observable by the current meat inspection. Furthermore, manual meat inspection techniques mediate cross-contamination with microbial pathogens, so should be omitted wherever the risk of inspection-mediated meat cross-contamination with microbial pathogens exceeds the risk of not detecting hazard(s) targeted by those techniques.

When considering how to make meat inspection truly *risk-based* and *target the most relevant hazards*, firstly, the hazards need to be identified and, secondly, they need to be risk-ranked. To control the most relevant meat safety hazards, the risk-based approach would logically include differentiation between, and risk ranking of, both incoming batches of animals (based on food chain information, epidemiological intelligence) and abattoirs (process hygiene assessment, performance). For both, appropriate targets/criteria would be needed. The control system for those hazards could include balancing between risk categories of the pig batches and risk categories of the abattoirs conducting slaughter, as well as process- and technology-based controls for higher-risk situations. Therefore, meat inspection in modern times cannot be seen as a stand-alone meat safety control, but has to be combined and compatible with process hygiene-based controls (see below). In terms of the underlining rationale/philosophy and its nature, such a more comprehensive and complex system represents a meat safety assurance system rather than meat inspection.

The role of abattoir process hygiene

The abattoir process hygiene issues and controls have been described in previous publications (Noerrung and Buncic 2008; Blagojevic et al. 2011; Buncic and Sofos 2012) which will be briefly outlined here. To reduce slaughterline contamination from incoming animals, the so-called "logistic" slaughter approach – slaughtering pathogen-free animals before pathogen-carrying animals – can be used. Once the slaughterline environment becomes contaminated, "secondary" sources of carcass contamination include aerosols, the contaminated surfaces and equipment/tools on the slaughterline, in the chiller and in the boning area. Both the relative relevance of individual sources for, and the overall extent of, microbial contamination of raw meat, are highly dependent on the technology and the level of the abattoir process hygiene. Hence fundamental differences exist both between abattoirs' technologies used for different red meat animal species (cattle, sheep, pigs, poultry) and within each species.

Therefore, a mandatory process hygiene management system, based on Hazard Analysis and Critical Control Points (HACCP) plans, has to be tailored for each abattoir individually. For the verification of the effectiveness of HACCP-based system in abattoirs, microbiological testing of carcasses is commonly used. This is usually done by determining whether counts of general hygiene indicator organisms on carcasses are within given acceptable ranges. The indicator organisms include "aerobic colony count" and *Enterobacteriaceae* count currently in the EU, or *E. coli* count in the USA. In addition, carcasses are tested for presence of *Salmonella* to determine whether its prevalence exceeds regulation-given acceptable values.

Should the results of these microbiological tests be unsatisfactory as a trend, the process hygiene is considered not to be under effective control so the meat safety risks are unacceptably high and thorough review/revision of the HACCP-based system is required. However, it should be kept in mind that, even in best abattoirs, total prevention of microbial contamination of all carcasses – and hence total absence of microbial foodborne pathogens – is unachievable under commercial conditions. Therefore, in situations where process-hygiene measures are properly applied but still further risk-reduction is necessary because the targets on final carcasses cannot be achieved, application of additional antihazard treatments of meat (i.e. surface decontamination/freezing/cooking) seems justifiable (EFSA 2011).

3. Need for further scientific research on above issues and related collaboration

Whilst sufficient knowledge has accumulated identifying the main concept of and approaches to modern meat safety assurance at abattoir level, as briefly indicated above, a number of knowledge gaps on some aspects and issues still exist. For that, further research is absolutely necessary to provide a sound scientific basis for further development, optimization, implementation and achievement of the desired effectiveness of the system. The issues requiring further research, in view of this authorship and as corresponding to scientific interest and expertise of related research groups, particularly include the following:

- Assessment and further optimisation of actual performances of each of the two main risk management strategies at abattoir level, *meat inspection* and *process hygiene*, in respect to both ensuring meat safety and contributing to public health; as well as developing related indicators and tools.
- Evaluation of the effectiveness of existing and/or development of new intervention strategies to reduce the biological meat safety risks at abattoir level, based on surface decontamination treatments (hides, carcasses) to control microbial hazards and/or treatments of meat (e.g. pasteurization/freezing) to control parasitic hazards.
- Epidemiology of foodborne pathogens along the food chain and evaluation of their sub-species (strain) diversity when exposed to existing and/or new intervention strategies and its relevance for the pressure-based selection of the hazards at abattoir level.
- Evaluation of the resistance development and transferability in microbial hazards when exposed to existing and/or new intervention strategies and its relevance for both meat safety and environmental protection.
- Identifying the optimal ways of combining the newly gained knowledge on the above issues into a coherent scientific basis for meat safety assurance system.

4. Particular research interests and experiences of the initiating FRST-NET members

It is well known that collaboration between different research groups in modern times is a pre-requisite for scientifically tackling more global problems and realizing solutions. The reasons for that include the fact that no group has all the expertise, experiences, facilities and resources at such a high level so to properly address all the open scientific issues at hand in a given area, including meat safety. Between-groups collaboration, however, enables a range of capabilities to come together, which can lead to reaching a “critical mass” and benefiting from the synergy. Consequently, a collaborative food-related network (FRST-NET) has been recently established, through forming an initial team comprising four Food Hygiene groups from Central Europe.

4.1 Risk-based approach to process hygiene- and meat inspection-based controls at abattoirs

This topic is a particular interest of the Meat Hygiene and Safety Group from Belgrade. The group is focused on epidemiology and control of bacterial foodborne pathogens (e.g. VTEC, *Salmonella*) at farm-to-abattoir stages in general, and on process hygiene and related decontamination strategies and risk-based meat inspection in particular.

4.2 Risk categorisation of abattoirs based on process hygiene performance

The current microbiological EU process hygiene criteria (PHC) applicable to abattoir operations (EC No 2073/2005; EC 1441/2007), communicates the expected outcome of a process as end-manufacturing or end-product criteria. Such PHCs define the expected final outcome of the processes, but they neither characterize nor differentiate between the processes themselves (EFSA 2007), hence they need to be further improved. Our research (Blagojevic et al. 2011) indicated that characterising each process and distinguishing between more or less hygienic processes in cattle and pig abattoirs solely through their fitting into acceptable, marginal or unacceptable category according to current EU PHC criteria based on indicator organisms levels (Total Viable count-TVC and *Enterobacteriaceae* count-EC) only on final carcasses was not sufficiently sensitive/effective. In contrast, when the same abattoir processes were characterised through a parameter based on the ratio between TVC or EC levels on carcasses and on skins in corresponding animals, the effectiveness of the processes in reducing the transfers of incoming, skin-borne microbiotaonto dressed carcasses could be determined more precisely, and processes which were less or more hygienic could be distinguished more reliably. The use of pathogen-based microbiological criteria for abattoir process characterisation does not seem recommendable, as pathogens occur on skins/carcasses relatively infrequently (compared with TVC and EC), in very low numbers, and distributed unevenly and also because they are affected not only by the processes' hygiene but also by the pre-abattoir chain of events. Rather, the main purpose of monitoring of pathogens on carcasses should be consumer exposure assessment and pathogen reduction programmes. However, further work, first to optimise a system for process hygiene performance of abattoirs and their related risk ranking, and then to define hazard-related targets to be achieved at final carcasses, is required.

4.3 Risk categorisation of animals at meat inspection

With the modern approach to meat inspection, the focus is on batch-based categorisation of animals into suspect (higher-risk) and non-suspect (lower-risk) batches before slaughter, based on so-called food chain information, pre-slaughter testing and *ante-mortem* findings (EFSA 2004). The assumption is that lower-risk groups can be subjected to simplified (preferably visual-only) *post-mortem* examination which would prevent inspection-mediated microbial cross-contamination (EFSA 2004). In our research involving bovines originating from 36 farms and pigs from 5 farms presented for slaughter (Blagojevic et al. 2011a), levels of one of the acute phase proteins (Haptoglobin-pH; indicating presence of inflammatory process, injuries or stress in animals) were determined in blood and the animals were subjected to routine meat inspection. No direct correlation between pH level and specific *post-mortem* abnormalities was found at individual cattle/pig level. However, at animal group level, the mean of pH values (in both cattle and pigs) were statistically significant higher in animals with abnormalities, than in those without abnormalities. The study indicated that the mean pH value in groups of cattle or pigs can be useful as an overall objective indicator of the overall status of cattle/pig batches when analysing the food chain information as a part of the *ante-mortem* inspection at abattoirs. Due to the large variability and nonspecific nature of pH-related responses in cattle and pigs, establishing a single, reliable cut-off pH value differentiating batches that may pose public health risks does not presently appear to bea realistic approach. Rather, establishing wider – "unsatisfactory", "marginal" and "satisfactory" – ranges of batch-based pH values indicating general appropriateness of the cattle/pigs source appears more promising. For that, further baseline studies of acute phase proteins, as well as other parameters for risk categorisation of animals, and their relationship with abnormalities in slaughtered animals are necessary.

4.4 Comparison of the public health protection performances of meat inspection and process hygiene

The risk management process - selection and implementation of measures for public health risk reduction to acceptable level - needs to be based on risk assessment outputs

(FAO/WHO 2006). Presently, there is no published assessment and comparison of performances of the two main meat safety strategies at abattoir level in the protection of public health: process hygiene and meat inspection. However, such knowledge is needed so to prioritize tasks, responsibilities and resources within the risk management context. Our ongoing research (Blagojevic et al. 2012) involving qualitative risk assessment of hazards of public health relevance, associated with operations of cattle and pig abattoirs, is based mainly on data on the occurrence of hazards on carcasses/meat and human exposure available from EU zoonoses monitoring system. In cattle abattoirs, among hazards that can be controlled by official meat inspection only, *T. saginata* cysticercus was found as posing medium risk, whilst all others were found as posing low or negligible risk. Among hazards that can be controlled by process hygiene in cattle abattoirs, *Salmonella* and VTEC were found as posing medium risk for public health, whilst all others were found as posing low or negligible risk. In pig abattoirs, among hazards that can be controlled by official meat inspection only *Trichinella* was found as posing medium risk, whilst all others were found as posing low or negligible risk. Among hazards that can be controlled by process hygiene in pig abattoirs, *Salmonella* was found as posing high risk and *Yersinia enterocolitica* as posing medium risk for public health, whilst all others as posing low or negligible risk. The study clearly indicated that – in modern times – both more hazards and higher risk categories of hazards can be controlled by process hygiene-based measures than by official meat inspection. Hence, presently, the former appears to have a higher public health protection potential than the latter. Further work is required to *quantitatively* determine, and compare, the exact contribution to protection of public health of these two fundamental meat safety strategies.

4.5 Epidemiology of microbial foodborne hazards and evaluation of the sub-species (strain) diversity when exposed to existing and/or new intervention strategies at primary production, at harvest and at post-harvest stage

These topics are a particular interest of the Department of Meat Hygiene and Technology from Brno and of the Centre for Veterinary Public Health, Institute of Food Hygiene in Leipzig. Research is mainly focused on introduction and distribution of foodborne pathogens into the meat processing chain as well as on typing and subtyping of selected foodborne pathogens (*Campylobacter* spp., *Salmonella* spp., *Yersinia enterocolitica, Clostridium perfringens, Helicobacter pullorum*). The aim is to identify the ways selected pathogens spread through food (including meat) chain, from the farm to the consumer, using different genotyping methods (e.g. PFGE, AFLP).

Concerning *Salmonella*, different studies were carried at the primary production and at the harvest level in the pork processing chain. They aimed both to examine *Salmonella* spp. prevalence in slaughter pigs as well as to evaluate risk management options at the farm level, e.g. by *Salmonella* vaccination of sows and piglets (Ludewig et al. 2001; Ludewig and Fehlhaber 2001; Roessler et al. 2006).

Additionally, our work was focused on the prevalence of *Campylobacter* spp. at different stages of the processing line, e.g. in the primary production of pig meat, the intra-herd distribution and at different stages of a turkey slaughter line (Alter et al. 2005a; Alter et al. 2005b).

The problem of diversity in microbial hazards is possible to divide in two levels. At first there is the problem of existing hazards of microbial foodborne pathogens such as *Salmonella*, *Campylobacter* spp., *Clostridium perfringens, Yersinia enterocolitica.* On the basis of subtyping and typing isolated strains from food or from human origin on the molecular level, we can recognise and describe them very elaborately. However, there are some ambiguities when it comes to confirming the transfer of these pathogens through all the food chain. Very often, we find different types of isolated strains from farm, from processing or from human patients.

On the basis of our experience,vector (poultry) can be confirmed in only 20% of human patient strains of *Campylobacter jejuni* i.e. some similar subtypes or types can be found on farm as well as on processing level. The PFGE and AFLP genotyping demonstrated that the *Campylobacter* population was genetically highly diverse. In human isolates, larger variability in PFGE polymorphisms was found. This corresponds with the relatively greater number of human samples. While in the sets of pig samples from a limited number of farms, related clones mostly originated in the same farm, human samples represent individual samples taken from a geographically extensive area. Different resistance profiles and genotypes of *C. coli* of human and pig origin suggested that sources other than pigs are more important in human campylobacteriosis.

A similar situation exists in the case of *Salmonella*. Very often, it is difficult to identify identical subtypes from human and from food chain. The second problem is data collection and its comparison between countries or institutions. It is absolutely important to use the same methods and procedures not only in laboratory testing and molecular typing but also in the methods of sampling. For example there are great differences in the occurrence of some pathogens if this are investigated via swabs from surface of carcases or via faecal content. Also, samples taken from rectum, cloaca or ileum are not the same in terms of *Salmonella* occurrence. For preventing zoonoses and reduction of occurrence of foodborne pathogens it is very important to focus on the control on the farms. If the contamination or occurrence of pathogens or parasites on the farm level is high, it is very difficult and disputable to use some corrective steps after slaughtering or during processing. Predictive monitoring on the farm level is necessary but it is very long-term, expensive and an organizationally demanding process.

Nowadays research is also focused on "new" or rediscovered pathogens, including for example, *Clostridium perfringens* or *Helicobacter pullorum* in poultry. After the ban on use of growth promoters, some of these pathogens have been again"discovered", because in the past they were suppressed by the use of antimicrobial growth promoters.

4.6 Evaluation of effectiveness of existing and/or development of new intervention (decontamination) strategies to reduce biological meat safety risks and its relevance for the pressure-based selection of the hazards at abattoir level

It is well established that even strict adherence to GHP during slaughter and dressing of carcasses cannot guarantee that carcasses, primary and finally, meat cuts, are free from pathogenic bacteria. By the same token, testing carcasses or meat cuts at the end of the processing line is neither an economic nor an effective mean of removing contaminated food from the chain. Also, the relation between pathogenic bacteria and marker organisms (i.e. non-pathogenic bacteria which can easily be detected and which give an indication of – often – faecal contamination) is sometimes weak, and it is not always easy to identify the source (human/animal origin) (Loncaric et al. 2009; Smulders et al. 2011b).

In can be argued that, whilst adherence to GHP will keep microbial contamination at a low level, and refrigeration and reduction of water activity will retard multiplication of bacteria, an additional array of measures will be needed, which are aimed to remove or inactivate contaminant microorganisms.

All institutes of the FRST-NET have focused a part of their research on new intervention methods (e.g. decontamination) at the harvest and post-harvest level to reduce biological risk in meat and meat products.

Some heat- or chemicals-based treatments aim at reducing microbial loads on animal coats (e.g. cattle hides) before skinning to reduce carcass meat contamination; reported microbial reductions in commercial abattoirs were 2-3 logs on hides or around 1 log on resulting carcasses (Buncic and Sofos 2012). Some alternative resin-based treatments aiming at "immobilising" microbiota on hides produced better effects on the microbial status of carcasses (Antic et al. 2011).

As regards fresh meat, antimicrobial treatments (decontamination) must not leave any residues in the food and should not alter the organoleptic properties. Some effort in this direction has been made by the Institute of Meat Hygiene, Meat Technology and Food Science at the University of Veterinary Medicine in Vienna. At slaughterhouse level, treatment of whole carcasses or contaminated regions only by steam / hot or cold water washes or sprays have been proven to effect a reduction of > 1 log cfu.cm^{-2}. This effect is improved when dilute organic acids are used together with or instead of hot water, and organoleptic changes in fresh meat can be minimized by careful adjustment of contact time-and temperature of acid/steam with the meat or skin surfaces (Smulders et al. 2011a and 2012). The concept has been currently extended to the meat cutting and packing area, by studying the antibacterial effect of polyamide films releasing lactic acid (Wanda et al. 2012, in press).

As compared to chemical decontamination of carcasses, treatment with "dry" technologies (e.g. UV or infrared light, pulsed light systems) – a research focus of the Institute of Food Hygiene, Leipzig – did not produce residues and did not elevate water activity on the surface of carcasses or meat. These non- or minimal-thermal technologies are promising tools for risk reduction in industrial meat processing chain.

When discussing benefits of all these new promising methods and before they should be used in practice, the possible risk in terms of resistance development has to be considered. For now, however, little information is available about the ability of microorganisms to become resistant to new intervention strategies (e.g. Pulsed Electric Field, High Hydrostatic Pressure, Cold Atmospheric Plasma treatment). Future studies are needed to understand the mechanisms behind these mechanisms. Furthermore, this research should also focus on changes in microbiota and in texture of meat and meat products and their consequences for further processing.

5. Further FRST-NET activities and steps

The representatives of Food Hygiene groups from four Faculties of Veterinary Medicine in central Europe: Brno (Czech Republic), Vienna (Austria), Leipzig (Germany) and Novi Sad (Serbia); held a meeting in Brno on 12 March 2012. The meeting resulted in the foundation of FRST-NET, and its members agreed to establish a long-term international scientific collaboration particularly to involve younger researchers from each group and to lead to applying for, and working closely together on, joint research projects.

Among the first activities in that direction, the second meeting of the FRST-NET will be held in Brno on 26th October 2012, where younger researchers from each group will: a) present their own recent and ongoing research activities; b) indicate their own particular capabilities; and c) put forward any ideas and proposals for future research and related collaborations. Subsequently, through discussions, possibilities and ways of operative and structured between-groups bilateral and/or multilateral cooperation will be identified.

Following these initial stages and the second FRST-NET meeting, it is expected that further activities of the FRST-NET will be directed towards obtaining grants for further practical actions that will include: implementing the agreements and plans made so far; preparation of new, more detailed operative plans; future expansion of the FRST-NET partnership (i.e. increasing the number of participating groups); practical realization of long-term joint research programme(s); and evaluation and validation of the research outcomes in the commercial setting involving a range of food business operators along the food chain.

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