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Meat inspection and interventions to control biological hazards in pig abattoirs in the European Union

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Background

Traditional meat inspection developed in the 19th century was used practically unchanged throughout the 20th century. It focused on controlling classical zoonoses which, however, became eradicated or rare in modern times. Currently, the main food safety risks associated with carcasses of slaughtered pigs include bacterial pathogens faecally excreted by healthy pigs. Because these "invisible" agents are undetectable by traditional meat inspection, it has been recognised that official meat inspection needs to be revised regarding better protection of public health *via* meat including pork. Accordingly, in the EU, a set of new legislation was introduced in 2004 ("food hygiene package"), which adopted novel key principles for modernised meat inspection. They focused on the use of risk assessment-based systems, verified through auditing mechanisms, as they have better potential to protect public health than traditional inspection. To help that and better link different players in the meat chain in achieving the common ultimate goal, safe meat, the use of Food Chain Information (FCI) was introduced. The main responsibility for meat safety was placed on the food business operator (FBO). Subsequently, to further improve the concept and the legislation, the EU Commission indicated its intention to use a generic framework, including appropriate indicators (criteria), which would allow Member States (MSs) to conduct their own risk analysis and adapt, where needed and possible, the most appropriate meat inspection methods. Accordingly, the European Food Safety Authority (EFSA) implemented a large scientific effort to identify directions for improvements to meat inspection, with clear focus on carcass meat safety and with the ultimate goal of better public health protection. In 2011, this resulted in EFSA's key scientific recommendations for improved meat inspection of pigs, to be achieved through a risk-based, comprehensive and coordinated carcass meat safety assurance system targeting the most relevant (priority) meat-borne hazards. The scope of this contribution is to overview the scientific principles, current status and perspectives of the work towards such improvements in the EU.

Need for and use of visual-only meat inspection

Published studies quantifying how much palpation and incision during examination of pig meat/organs mediate microbial cross-contamination of meat with e.g. *Salmonella* and *Yersinia* are lacking, but based on most fundamental food hygiene principles it can be assumed that it is happening. EFSA's scientific opinion stated that the public health risk generated by palpation/incision of carcasses from non-suspect animals is likely higher than the public health risk posed by the abnormalities found by those techniques. Moreover, the abnormalities found are largely of animal health relevance or quality issues rather than pork safety concerns. Therefore, omitting palpation/incision during *post-mortem* inspection of non-suspect pigs is considered as providing overall microbial meat safety benefits, although in suspect animals, the use of those manual techniques may be needed. A number of studies conducted in different countries indicated that the hands-off approach is justified and enabled a gradual shift from traditional inspection to visual-only pig meat inspection. They also showed that the change from traditional to visual-only inspection method poses negligible, or low at most, increase of the public health risk. Accordingly, the EU Meat Inspection Regulation 854/2004 was amended with Regulation 2018/2014 and visual-only inspection became the standard pig meat inspection method in the EU. The most recent EU Meat Inspection Regulation 2018/2014 does not differentiate between pig age or production systems, and allows visual-only inspection for all categories of pigs. Nevertheless, because manual examination continues to be relevant in the case of suspect/high-risk pigs and when required by international trade partners, alternative techniques aimed at avoiding cross-contamination caused by palpation/incision have been investigated. The proposed solutions include, for example, disassembled slaughtered-scalded pigs from outside-in as well as using imaging (vision) technology to detect and differentiate abnormalities on carcasses and organs including contamination. It has to be kept in mind that visual-only inspection has been introduced to improve control of public health hazards, but omitting palpation/incision can reduce the sensitivity of detecting some animal health/welfare hazards. Hence, further work is needed regarding the contribution of meat inspection to the overall surveillance/monitoring of pig health and welfare.

Need for and use of Food Chain Information

The main intention with the Food Chain Information (FCI) in the risk-based pig meat inspection system is evidence-based risk categorisation of incoming pigs regarding their hazard burden (i.e. farms of

origin) as well as of the slaughterline processes regarding their risk-reducing capacity (i.e. abattoirs). Then, an informed decision on the best way to achieve targeted pig meat safety of the final carcasses can be made. For proper use of FCI, systematic collecting, recording, reporting and analysing of the necessary data are required. That can include historical hazard-testing data (on-farm and at-abattoir); production practices and risk-reduction interventions applied, data from Hazard Analysis and Critical Control Point (HACCP) verification, historical meat inspection data, and harmonised epidemiological indicators (HEIs) related to individual hazards in pigs (on farm) and meat (at abattoirs). In the EU, FCI is defined in Annex II of EU Regulation 853/2004 which relates mainly to the animal herd and its owner. The HEI is a relatively new concept, proposed and generically outlined by EFSA, in which a range of data from hazard testing in animals and carcasses and/or from auditing the farming and transport-lairage practices can be used. For that, each HEI's purpose, methodology, criteria separating acceptable from unacceptable, practicality and cost-benefit have to be determined. This requires good coordination along the meat chain and harmonisation of the regulatory system. With forward flow of FCI, the main benefits would include dividing incoming pigs at the abattoir based on their hazard status, e.g. level of *Salmonella*, which would enable the abattoir to choose and focus on the most beneficial control measures for those particular pigs. However, for that, a surveillance program is required, but currently it is run only in relatively few EU MSs, probably due to financial and practical constraints. With backward flow of FCI, the main benefits would include improving on-farm pig health, as information from abattoirs includes the various abnormalities/lesions found at *post-mortem* inspection. Nevertheless, the intended on-farm benefits are not always achieved, because of variations in how the abnormalities during meat inspection are categorised and recorded, and because some producers do not fully convert the feedback received into actions for improvements. Overall, while the potential of the FCI system has been recognised, it remains not fully developed and is underutilised in practice at present. The main reasons for that might include unclearness of what information is required from and insufficient/inaccurate information provided by individual players in the meat chain, as well as using FCI disjointedly from other control strategies with which it is supposed to go hand-in-hand. Some surveys indicate that FCI works noticeably better in the meat chains that are more integrated and comprise larger FBOs than in less integrated chains with smaller businesses, which seems logical. Further work is needed to identify the FCI system's specific objectives more clearly and translate them into meaningful parameters on which all the meat chain players can act efficiently. Further work is also needed on other existing aspects of FCI, e.g. improving the abnormality-recording system in meat inspection, fully developing HEIs, and evaluating some potentially useful novel tools (e.g. multi-serological/microarray herd profiles for priority hazards and potential use of Acute Phase Proteins levels in serum).

Generic framework for risk- and food chain-based meat safety assurance in pig abattoirs

For effective control of the priority hazards on pig carcasses, a range of measures need to be applied through a comprehensive, coordinated and risk-based carcass meat safety assurance system. In EFSA's scientific opinion on revision of pig meat inspection from 2011, a generic framework for such a system was outlined. Its main aspects include utilisation of the following data in a coordinated way: identification and traceability of pigs and meat; FCI focused on risk-reduction performances of farms and abattoirs to risk categorise both businesses; hazard control measures applied through Good Manufacturing Practice and Good Hygienic Practice (GMP/GHP)- and HACCP-based programs; and control measures through meat inspection *per se*. In such a system, well regulated, measurable meat safety targets and incoming animal-related safety targets are both needed. Assurance that each abattoir's system works as expected is provided through official verification and auditing, meaning the targets are met.

Control of priority bacterial hazards

Whether and how much pig carcass meat will be contaminated with *Salmonella* and/or *Yersinia* is primarily dependent on: a) the presence and level of these hazards in/on pigs delivered for slaughter (hence, the performance of the farms of origin), and b) the extent the hazards are transmitted from pigs and the abattoir environment onto the meat (hence, the hygiene performance of the abattoir). On the farms, *Salmonella* and *Yersinia* shed by asymptomatic pigs can be spread *via* feed-animal, animal-animal and animal-environment-animal routes, and total elimination of these hazards is possible but difficult to achieve. To minimise the risk, a range of on-farm control measures can be considered, and it is up to the risk managers to decide, within their specific situation and conditions on their farm, how much emphasis and what resources should be put on any of the individual options to achieve the targeted outcome.Contamination of carcasses with priority bacterial hazards (*Salmonella* and *Yersinia*)

in abattoirs occurs mainly due to direct or indirect contamination by faeces from those animals shedding the hazards. Hence, control measures in abattoirs aim at improving the process hygiene and effective cleaning-sanitation regimes. Because abattoirs differ regarding technology/equipment, extent of standardisation, available expertise, hygiene training and application, and motivation of staff and management, they can be categorised in respect of their risk reduction capacity. This can be achieved through the Process Hygiene Criteria (PHC) which include the maximum values for indicator bacteria (total viable count and *Enterobacteriaceae* count) and prevalence of *Salmonella* on the final carcasses. If these PHC are not met, the abattoir processes must be improved, but the product (meat) is not withdrawn from the market. For *Yersinia*, no such PHC exist in the current EU legislation. Information on risk category of each abattoir is useful, as it is unlikely that, for example, a high-risk abattoir (i.e. with low risk-reduction capacity) would handle incoming pigs posing high *Salmonella/Yersinia* risk effectively enough to reduce to an acceptable level the risk of pathogens being present on carcasses. The main process hygiene-based control measures regarding priority bacterial hazards on pig carcasses include: effective sanitation of trucks and lairage, logistic slaughter (low-risk/sero-negative pigs first), proper scalding in clean water (e.g. at 62°C), effective cleaning-sanitation and optimal design of de-hairing machines, ensuring good quality singeing (at 1300-1500°C) of the skin after de-hairing, making sure subsequent skin polishing does not negate the desirable effects of singeing, hygienic evisceration (sealing the rectum, prevention of gut content spillage), handling-removal of the tongue without cross-contaminating the carcass, preventing aerosol-mediated cross-contamination during carcass washing, and effective chilling of carcasses (≦7°C). Various carcass decontamination treatments can be used to further reduce priority bacterial hazards on pig carcasses, when the meat safety target cannot be achieved through process hygiene measures only. Note that carcass decontamination is an additional measure but is not a replacement for proper process hygeine-based control measures. Information on the effects of decontamination specifically on *Salmonella* and *Yersinia* on pig carcasses is relatively scarce. Rather, the large majority of published studies reported the achieved reductions of general microbiota including fecal indicators. Nevertheless, it was shown that various hot water treatments (e.g. 80°C/15 sec) can reduce *Salmonella* counts on pig carcasses. Care must be taken when selecting temperature-time regimes as some meat discoloration can occur in the process, either temporary/reversible or more permanent. Also, 2% lactic acid treatment can reduce *Salmonella* prevalence by two-fold. Higher acid concentrations are more effective, but detrimental effects on meat colour/flavour were observed in such cases. To enhance the antimicrobial effects, organic acid treatments can be combined with pre-treatment of carcasses with hot steam. Other carcass decontamination treatments reported include combinations of steam (130°C) and ultrasound (30-40 Khz), or steam and vacuum. Quantitative information on *Salmonella* reductions achieved by decontamination of pig carcasses is very limited, and for *Yersinia* it is lacking, but based on measuring other bacteria on pig carcasses or carcasses of other red meat animal species it seems that 1-2 log reductions of these pathogens could be achievable. It should be noted that a risk assessment conducted by EFSA in 2010 indicated that a reduction of two logs (99%) of *Salmonella* numbers on contaminated carcasses would result in more than 90% reduction of the number of human salmonellosis cases attributable to pig meat consumption, while a reduction of one log (90%) would lead to >80% reduction of human cases.

Control of priority parasitic hazards

In pigs on-farm, the presence/levels of *Toxoplasma gondii* and *Trichinella* are affected by zoo-sanitary conditions (e.g. biosecurity), whether the farm is an intensive or extensive system, if it is indoor or outdoor farming, and whether the pigs are fattening or breeding animals. Generally, in pigs raised in intensive, indoor farming systems, the occurrence of both parasites is lower than in smaller, outdoor farming systems, which can be utilised to differentiate farms/herds into lower and higher risk in the context of FCI. In addition, historical parasite testing data from the same farms/herds, monitoring, and epidemiological situation/geographical risks, including HEIs, can be fed into the FCI. According to the current EU Directive 2015/1375, only pigs from farms with low biosecurity are required to be tested for *Trichinella*, while those from farms with high biosecurity (controlled housing) are exempt, and the requirements for a herd to be officially recognised as a holding or as part of a controlled housing compartment are enlisted in Annex IV of the *Trichinella* Directive. The compliance is assessed through regulatory or independent third-party auditing. At the abattoir, if incoming batches of pigs are categorised as *Trichinella and/*or *T. gondii* low-risk (based on FCI and historical testing data), they do not have to be tested for these parasites or subjected to any parasite-inactivation treatments. Otherwise, for detection of *Trichinella*, the artificial digestion method is used. Currently, pig carcasses are not mandatorily tested for the

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