THE USE OF RISK ASSESSMENT TO SUPPORT CONTROL OF SALMONELLA IN PORK

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Introduction

Salmonella is one of the major zoonotic foodborne pathogens worldwide and pork products have been identified among the main sources of salmonellosis in humans. In some countries, like Brazil, relatively high prevalences may be found in pig herds and among carcasses at slaughter (Schwarz et al. 2010). In Denmark, a contingency plan has been in place but nevertheless domestic pork is still estimated to be the most important food source for salmonellosis, as it is in the EU as a whole (Anonymous 2015). Therefore, there is a continued focus on the identification of effective intervention measures in the pig and pork production chain. In this keynote, an overview will be given of some research projects that have been performed to study the potentials of interventions in the pork production chain. The specific objective in these projects was to estimate their effectiveness in terms of reduction of the public health risk of salmonellosis. The results illustrate how a quantitative microbiological risk assessments (QMRAs) approach can be applied to support the control of Salmonella in pork.

QMRA for Salmonella in pork

Quantitative microbiological risk assessment (QMRA) is an approach to integrate scientific data and knowledge with food processing information, in a transparent and logical structure. It offers a decision support tool for food safety risk managers by an assessment of the public health burden associated to microbial hazards and food products and a platform for comparative evaluation of different options for intervention and control. In so-called “farm to fork” risk assessments, the effectiveness of intervention measures at the farm, during transport, slaughter and processing, and the stages beyond that, can be quantified and compared in terms of expected health risk reduction. This is particularly useful for a zoonotic disease like salmonellosis from pork, which may be transmitted from the life animal, via the production chain, to the consumer. Until now, several authors have published QMRAs related to Salmonella in pigs and pork (e.g. Bollaerts et al. 2009, Corbellini et al. 2017). A major one is the “farm to fork” risk assessment performed for EFSA (Snary et al. 2016), which is based on a combination of well-developed models for different parts of the pork production chain, applied to different EU Member States. From this QMRA, it is concluded that interventions are best focused on reducing the level of Salmonella in the feces, preventing fecal contamination of the carcass or on reducing the level of contamination at the end of processing.

The slaughter process

One challenge of a QMRA for Salmonella in pork is the description of the slaughter process of pigs, where the intestinal content of the animals is generally
considered the main source of carcass contamination. A quantitative description of this process is needed to translate prevalence and concentrations of *Salmonella* into exposure, and to assess the effects of interventions reducing them (Swart et al. 2016a). Here, a complication is that the *Salmonella* that ends up on the chilled carcass after slaughter can originate from the hide and from feces, and this feces can be of the animal itself and from other animals (Nauta et al. 2013). As shown by Smid et al. (2012), the house flora in slaughter environment is also an important source of *Salmonella*. Interestingly, even the meat inspection itself can contribute to cross-contamination between carcasses, be it with low levels of *Salmonella* (De Freitas Costa et al. 2016). Due to the variation in slaughter practices between slaughterhouses and the variation between pigs, the importance of the different sources and their impact on the contamination of the chilled carcasses is highly variable and hard to predict. Therefore, alternative approaches have been taken to study the impact of the slaughter process on pig carcass contamination and to assess the effects of potential interventions during this process.

### The use of fecal indicators during slaughter

A Danish project (DECONT) aimed to study carcass contamination and the potential effectivity of decontamination of pig carcasses during slaughter. In this project, samples were taken from 2822 pigs in five different slaughterhouses and quantitative samples were taken for fecal indicator bacteria (*E. coli*) and *Salmonella*. The hypothesis was tested that *Salmonella* contamination of carcasses originates from the animal itself and could be predicted from the fecal carriage of *Salmonella* and the fecal contamination of carcasses, as predicted from *E. coli* data in animal feces and hygiene performance of the slaughterhouse. This hypothesis could not be confirmed (Nauta et al. 2013), which suggests that other factors than hygiene performance may affect the *Salmonella* status. Another indicator, *Enterobacteriaceae*, was used in Brazil (Corbellini et al. 2016). Although a statistically significant association between the log of the *Enterobacteriaceae* count and the *Salmonella* occurrence was found, the variation in *Salmonella* contamination per day was a dominant factor, which made the *Enterobacteriaceae* as indicator for hygienic failure unsuitable as indicator for *Salmonella* contamination.

### The consumer phase

Another special challenge in “farm to fork” models is the consumer phase, where the consumers buy, transport, store and prepare their pork products. The transfer, growth and survival of *Salmonella* during this phase are difficult to predict due to a large variation of pork products, a large variation between consumers and scarcity of data. Also, consumers cannot be enforced to comply with regulatory hygiene standards or storage conditions. Yet, the consumer phase is the stage where exposure occurs and therefore it is of crucial importance for the assessment of the human health risk. Models targeted at specific products (like meatballs, pork cuts and fermented sausages) and specific populations have been developed (e.g. Møller et al. 2015, Swart et al. 2016b), but may not be generally applicable for all pork products consumed. Therefore, an alternative generic approach was developed that strongly simplifies the consumer phase and is based on an epidemiological estimate of incidence of salmonellosis (Duarte et al. 2016). It allows us to estimate the effects of interventions that modify the concentrations on the carcass in terms of relative risk reduction for the consumer.
Impacts on human health risk

Using this approach, Duarte et al. (2016) were able to assess the risk reducing effects of different experimental carcass decontamination scenarios in the DECONT project. An interesting finding was that it is important to not only estimate the mean effect of decontamination in terms of log reduction obtained, but that an estimate in the variation of that effect is at least as important. In general, a larger variation in the effect will lead to a reduced efficiency of carcass decontamination. Hence, the most effective decontamination strategy is not only effective in terms of mean log reduction, it also shows little variation in its effect, in particular for decontamination methods with mean effects around 1 log reduction, like lactic acid treatment. For heat treatment with mean log reductions between 2 and 3, the effect of variation was less pronounced.

Towards risk-based criteria

The same model principle was applied by Bollerslev et al. (2017a and 2017b), who studied the feasibility of using either enterococci or E.coli as an indicator for the presence of higher concentrations of Salmonella on pig meat. The prevalence of Salmonella was positively correlated to the concentration of the indicator. A positive association was also found between the concentration of Salmonella and the concentration of the indicator, but only for Salmonella positive samples. More specifically, the objective of these studies was to develop an approach that could make it possible to define microbiological limits for a bacterial indicator that is associated with an increased risk of salmonellosis, due to bacterial growth in the fresh meat chain or improper hygiene at the slaughterhouse. It was estimated that the majority of salmonellosis cases, caused by the consumption of pork in Denmark, is caused by the small fraction of pork products that has enterococci concentrations above 5 log CFU/g. The results obtained can be used to evaluate the potential effect of setting different microbiological limits on the risk of salmonellosis and consequently they may be used for the definition of a risk-based microbiological limit for enterococci and development of a process hygiene criterion in cutting plants and retail butcher shops. At slaughter, Salmonella may continuously be brought to the slaughter line by intestinal carriage of pigs. Therefore, the ability to control fecal contamination through good slaughter hygiene management is crucial. The risk model allows us to associate a hygiene level measured by E. coli to a possible Salmonella consumer risk. In this way a more risk-based approach for setting criteria in slaughterhouse HACCP programs has been developed.

Discussion

These results show that quantitative microbiological risk assessment allows an evaluation of the effect of control measures to reduce Salmonella in pork, in terms of reduced risk of salmonellosis. Its strengths are that it allows a transparent comparison of interventions and control measures in different parts of the chain, and can translate their effectivity in terms of relative risk reduction for the consumers. Both are of major importance for food safety risk managers. Challenges are the variation of processing practices and their potential effects on the transfer and survival of Salmonella, as well as the uncertain impact of the simplifying assumptions that have to be made when a QMRA model is constructed. Further research to meet these challenges will further strengthen the importance of QMRA as a tool to practically support decision making about microbial safety in the pork production chain.
References


