Summary: Measures concerning the production of microbiologically safe meat can be divided into those guided by the more or less classical, rigid “legislative” approach and by a more flexible “scientific” approach based on risk analysis. Therefore intervention should not unduly focus solely on the abattoir or food processing stages as is done with the classical, rigid “legislative” system, but should also target the risks associated with preharvest production stages. A comparison between the “legislative” and the “scientific” approach shows that properly structured HACCP-like systems, applied from farm to fork, as proposed by the new EU legislation and the Dutch implication of an integrated quality control system offer the best available approach to food safety assurance.

Keywords: HACCP; Databank; Salmonella; sampling; pork; decontamination

Introduction: The infection and contamination of pork and pork products by pathogenic bacteria have often been epidemiologically linked to food borne illness in humans. Risk analysis shows that microbial organisms on pork represent the greatest risk to public health. The level of exposure of consumers to microbiological hazards in fresh pork is unlikely to be reduced significantly by the detection and removal of gross abnormalities in the tissues examined, as is done by the to-day’s meat inspection. Among the agents involved in pork are Salmonella spp., Campylobacter spp., Yersinia enterocolitica and Listeria monocytogenes. Most of the research on pathogens in pork is focussed on Salmonella. Inspection at the end of the production-line is not designed or equipped to detect symptomless carriers of zoonotic agents or residues and may be in some cases even contra-productive regarding the hygienic aspects of the production process (Anon. 2000). In modern
animal husbandry large numbers of pigs are raised under optimised hygienic conditions. These conditions however do not guarantee pathogen-free pigs at slaughter. Other live animals and the environment during transport and the period prior to slaughter may serve as a source of pathogenic micro-organisms, which in turn contaminate carcasses during the slaughtering process as well as meat products during further processing, storage and handling.

**Integrated Quality Control System**: In an integrated quality control system information from the farm is an essential element to ensure safe meat (Anon. 2000). Traceability for all animals is a prerequisite. The competent veterinary authority should collect data using harmonised sampling methods. The information stored in a central databank should cover:
- the nature and origin of the animal feeding,
- the health status of the animals at the farm,
- the use of veterinary medical products,
- the results of any analysis carried out on samples taken at the farm as well at the slaughterhouse,
- results of slaughterhouse data regarding ante- and post-mortem findings.

This information is needed by the meat inspection as well as by the slaughterhouse management as a tool for steering the HACCP like system. In such an integrated system it is possible to allow a visual post-mortem system only. The advantages of omitting particular measures such as palpation and slicing, mentioned in the to-day meat inspection and replace them by only visual inspection are:
- reduction of cross contamination;
- reduction of unnecessary damage to the carcasses;
- better application of resources to more appropriate sanitary measures.

Animals lacking the above-mentioned information cannot be accepted in such control system but have to be slaughtered separately. In addition they will undergo extensive post-mortem inspection and sampling for further laboratory examinations. The farmer has to pay for the cost of the extra analyses and inspection labour.

**Presence of Salmonella**: The prevalence of Salmonella differs between slaughterhouses and sampling days and is also dependant upon which part of the pig is sampled. This was illustrated by a survey conducted by Swanenburg et al. (2001) of 925 slaughter pigs sampled at six different locations. The highest prevalence of Salmonella was observed in the rectal contents (25.6%), whereas the lowest prevalence of Salmonella was observed on the carcasses (1.4%). The prevalence of Salmonella was 19.6 % in tonsils, 9.3 % on livers, 9.3% on tongues and 9.3 % in mesenteric lymph nodes. Salmonella was isolated from one or more samples of 47 % of the pigs. S. typhimurium was the most frequently isolated serotype. Based upon these observations, the results of Salmonella isolations of slaughtered pigs should always be carefully interpreted, with due account being given to which kind of sample has been examined.

**Control in slaughter lines**: Regarding microbiological Food Safety Requirements (FSRs) a distinction can be made between hygiene guidelines and guidelines to prevent pathogenic micro-organisms arising in foods of animal origin.

Regarding the hygiene guidelines, an EU Commission Decision of 8 June 2001 has been published to introduce compulsory testing and evaluation of the total viable counts and Enterobacteriaceae on carcasses and working surfaces (Anon.,2001). The daily log mean value for acceptable results for samples taken by the destructive method for pigs must be less than 4.0 log N total viable counts per cm² and for Enterobacteriaceae less than 2.5 log N per cm² (Table1). Between 5 and 10 carcasses should be sampled on a single day. Samples should be pooled from ham, back, belly and jowl of the tested pig carcass. Swab sampling removes only a proportion of the total flora present on the meat surface (Snijders et al, 1984). Where methods other than the destructive method are used, the microbiological performance criteria must be established individually for each method applied in order to relate them to the destructive method.
Table 1: Daily log mean value for marginal and unacceptable results for bacterial performance criteria for pig carcasses (cfu cm⁻²) for samples taken by the destructive method

<table>
<thead>
<tr>
<th></th>
<th>Acceptable range</th>
<th>Marginal range (&gt;m but &lt;M)</th>
<th>Unacceptable range (&gt;M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total viable count</td>
<td>&lt;4.0 log</td>
<td>4.0 log – 5.0 log</td>
<td>&gt;5.0 log</td>
</tr>
<tr>
<td>Enterobacteriaceae</td>
<td>&lt;2.0 log</td>
<td>2.0 log – 2.5 log</td>
<td>&gt;2.5 log</td>
</tr>
</tbody>
</table>

The method used for the bacteriological sampling for checks of cleaning and disinfection efficiency in pig slaughterhouses and cutting plants has also been described (Table 2). The use of the contact plate method and the swab technique is limited to the testing of surfaces, which are cleaned and disinfected, and are dry, flat, sufficiently large and smooth.

Table 2: Mean values for the number of colonies for testing of surfaces

<table>
<thead>
<tr>
<th></th>
<th>Acceptable range</th>
<th>Unacceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total viable counts</td>
<td>0 – 10 / cm²</td>
<td>&gt;10 / cm²</td>
</tr>
<tr>
<td>Enterobacteriaceae</td>
<td>0-1 / cm²</td>
<td>&gt;1 / cm²</td>
</tr>
</tbody>
</table>

While these criteria facilitate the control of general hygiene in meat plants, they do not address the question as to whether or not a carcass may be deemed to be free of pathogenic bacteria of human importance. There is therefore a need for the development of guidelines for pathogenic microorganisms not alone on carcasses but also in food animals at various stages in the course of production. Such guidelines should be based on reliable data and take account of the prevalence of these hazards. This is clearly illustrated by Swanenburg et al. 2003.

Origin of contamination: Experiments carried out in Dutch pig slaughterhouses which slaughter 400 to 650 pigs per hour showed that pigs originating from a Salmonella-infected farm have a higher chance to end up as the primary source of Salmonella-contaminated pork and are also a substantial source of the contamination for the environment, trucks, lairage, slaughter-line and pigs from other herds. A major factor which leads to the contamination of pork with Salmonella is the exposure of pigs to infection in the lairage in slaughterhouses. Herd serology is significantly associated with the occurrence of Salmonella in rectal contents and lymph nodes of the pigs. This parameter can be used to distinguish between the Salmonella risks posed by individual herds and farms. Sero-negative herds should not be slaughtered together with sero-positive herds in the same slaughterhouse. Inter-mixing of animals as well as meat derived from pigs from sero-positive and sero-negative herds somewhere in the production and processing chain will not result in a sufficient solution of Salmonella contamination of the final product.

There is now a good understanding of the possibilities for addressing the Salmonella problem in pork production. However, contamination of pigs with Salmonella should be avoided in all phases of the pork production chain (Lo Fo Wong and Hald, 2000).

The Danish Salmonella Surveillance and Control Programme, which has been in use since 1995, is based on serological testing of the Salmonella status of almost every pig farm. This programme has resulted in a reduced number of highly infected farms, but so far has not resulted in a substantial decrease in the rate of Salmonella contamination of pork. Control measures such as the avoidance of direct and indirect contact between Salmonella-free and Salmonella-positive herds are not yet implemented in this programme. First and foremost, such contact either direct or indirect, between different herds must be prevented along the entire pork production chain, and especially between known Salmonella-free and Salmonella-infected herds, so that no cross contamination between
herds can occur. Likewise, salmonella-free animals must not be exposed to Salmonella-contaminated environments such as trucks and lairages of slaughter houses where such animals may become infected by taking up contaminated water or faecal material from ramps, walls and floors. It is essential that control measures involving the farm as well as the transport, lairage, slaughter and deboning phases, be effectively introduced.

**What has been neglected?**

Since it is acknowledged that the dressed carcass harbours a complex microflora on its surface, additional on-line microbial decontamination procedures may be required. Such procedures are currently under consideration by both the meat industry and the EU authorities. However, their implementation on slaughter-lines in the EU has not met approval to-date. Yet the only realistic approach to de-contamination of a dressed carcass is the treatment of carcasses at the slaughter-line using methods as heat, chemical treatment or ionising irradiation. Of these, chemical treatment using approved substances (e.g. organic acids and trisodium phosphate) which have met all the necessary safety requirements, appears to be the preferred option. Such an approach has already received the approval of the USDA.

Although the food industry including farmers have the responsibility for the production of safe meat, failures in the supply chain will occur from time to time. Finally, it is very important that the information and advice given in consumer education programmes and on food labels regarding pathogenic micro-organisms is accurate and presented in a user-friendly format, so as to ensure that consumer can play his or her role in preventing the transmission of foodborne hazards.

**References:**


