Research on the dynamics of *Salmonella* spp. infections in fattening pig herds in north-western Germany

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**Abstract**

Pork represents one major source of human *Salmonella* infections, but on-farm control strategies for *Salmonella* contamination are still insufficient. The aim of this study was to localize “hot spots” of *Salmonella* reservoirs in the course of the fattening period. In a longitudinal study 12 farms with high *Salmonella* prevalence were examined periodically, starting in the disinfected empty compartment, followed by four subsequent samplings every four weeks. Each sampling comprised faecal and environmental samples, always taken from the same locations, i.e. nipple drinkers, feeders, chains, pen walls (localizations with continuous animal contact), guide boards, passageways, feed tubes, ventilation (localizations without continuous animal contact). Samples were examined by culture and PCR. Overall, 106 out of 1047 samples were culturally *Salmonella*-positive, resulting in an overall detection rate of 10.1%. Farm specific detection rates ranged from 1.7% to 24.1%. Four farms did not yield *Salmonella* isolates. The average detection rate in samples “with animal contact” was 8.1% compared to 10.9% in localizations without animal contact. Overall 2.2% of the samples “with animal contact” were positive prior to actual contact, 11.3% at the second, 12.8% at the third and 13.3% at the fourth sampling. In contrast, detection rates in samples “without animal contact” were 12.6%, 13.8%, 14.2% and 12.9% from the first to the fourth sampling. The higher *Salmonella* detection rates in localizations without animal contact indicate a neglect of disinfection measures at these spots compared to localizations with continuous animal contact, being in the focus of hygiene management. This thesis is supported by the low percentage of positive samples from localizations with animal contact at the sampling after disinfection opposed to relatively high detection rates in samples “without animal contact” already then. Thus, especially these spots often underestimated as infection sources may form *Salmonella* reservoirs and should be included explicitly in the hygiene management.

**Introduction**

Pork represents one major source of human *Salmonella* infections (STEINBACH and HARTUNG, 1999). In terms of risk assessment, the prevention of introducing *Salmonella* into the food chain is a prerequisite and should start at farm level (regulation [EC] 2160/2003; EFSA, 2006b). Since different mechanisms influencing the *Salmonella* prevalence in pig herds are already known, the determination of risk factors maintaining the horizontal intake as well as the vertical infection from sows to piglets and the circulation of *Salmonella* within pig herds is necessary to support prevention programs (BLAHA, 2001, STEINBACH and KROELL, 1999). The hygiene management was identified as one important risk factor and thorough disinfection measures were proposed to enhance the control of *Salmonella* infections on-farm (STEINBACH and KROELL, 1999). However, *Salmonella* reservoirs are still present and detailed knowledge about their relevance is lacking. The aim of this study was to localize “hot spots” of *Salmonella* reservoirs in the course of the fattening period in different farms.

**Material and Methods**

A longitudinal study was performed in twelve fattening pig herds in north-western Germany in an area of high pig density. All these farms were categorized as having a high risk of *Salmonella* contamination...
according to a German Salmonella monitoring system for slaughter pigs. This means, more than 40% of at least 60 pigs tested at the abattoir via enzyme linked immuno-sorbent assay (ELISA) applied to meat juice were serologically Salmonella positive during the past twelve months.

The sampling scheme for each farm included periodic samplings taken during the course of a fattening period in one randomly selected fattening compartment. In three farms, the samplings were extended to a second fattening period, in five farms even to a third one. The first testing always took place in the cleaned and disinfected empty compartment as well as on the transport vehicle delivering the piglets. This was followed by up to five further samplings (depending on the length of the fattening period in each farm) every four weeks. Each sampling comprised between 13 and 24 samples (depending on the individual situation on each farm), consisting of collective faecal samples and environmental samples. The faecal samples were taken from the floor of the pens with gaze tissue. The environmental samples were taken by wiping the related surfaces with peptone water saturated swabs. These included localizations defined as having continuous animal contact, such as nipple drinkers, feeders, chains and pen walls. Other sampling localizations, all lacking in frequent or any animal contact, were guide boards, passageways, feed tubes, ventilation, windows, scales and boots. In addition to that other environmental samples such as rodent faeces or insects were also collected where found.

The samples, containing approximately 10 grams (g) of material (environmental samples) or 25 g (faecal samples) were put into plastic bags with 90 millilitres (ml) (environmental samples) or 225 ml (faecal samples) of buffered peptone water. After 24 hours of incubation at 37°C 1.5 ml of each sample were transferred into reaction tubes and sent to the Robert-Koch-Institute for cultural examination (DIN EN ISO 6579).

Results

Overall, 1047 samples were collected on the twelve farms and examined for Salmonella species (spp.). The agent was detected in 106 of these samples, resulting in an overall detection rate of 10.1% (Tab. 1). Farm specific detection rates ranged from 1.7% on farm B to 24.1% on farm L. The farms A, C, D and K were not positive in any sample.

Ordered by sampling localization independent of sampling time, it was shown that different sample sites gave similar detection rates (Tab. 2). From 408 environmental samples originated from localizations with continuous animal contact 8.1% were culturally Salmonella spp. positive, whereas 10.9% of 466 samples from localizations without continuous animal contact were Salmonella spp. positive.

Tab. 1: Number of samples and detection rate of Salmonella spp. on farm level

<table>
<thead>
<tr>
<th>Samples</th>
<th>Farm No.</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>all</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
<td>F</td>
<td>G</td>
<td>H</td>
<td>I</td>
<td>J</td>
<td>K</td>
</tr>
<tr>
<td>Total (n)</td>
<td>68</td>
<td>60</td>
<td>55</td>
<td>101</td>
<td>117</td>
<td>221</td>
<td>59</td>
<td>101</td>
<td>90</td>
<td>67</td>
<td>54</td>
</tr>
<tr>
<td>Positives (n)</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>6</td>
<td>40</td>
<td>0</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Positive (%)</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>4.0</td>
<td>5.1</td>
<td>18.1</td>
<td>0.0</td>
<td>13.9</td>
<td>15.6</td>
<td>20.9</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Tab. 2: Number of samples and detection rate of Salmonella spp. per group of sample sites

<table>
<thead>
<tr>
<th>Localization</th>
<th>Samples</th>
<th>transport vehicle</th>
<th>collective faeces</th>
<th>environment with continuous animal contact</th>
<th>environment without animal contact</th>
<th>continuous insects/rodents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (n)</td>
<td>29</td>
<td>70</td>
<td>408</td>
<td>466</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>Positives (n)</td>
<td>6</td>
<td>8</td>
<td>33</td>
<td>51</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Positives (%)</td>
<td>20.7</td>
<td>11.4</td>
<td>8.1</td>
<td>10.9</td>
<td>10.8</td>
<td></td>
</tr>
</tbody>
</table>
In order to demonstrate the time-variant development of the two different groups of sample sites mentioned above, positive results were subdivided according to the time of sampling within the fattening period: obtained from the cleaned and disinfected empty compartment at the day of housing in (first sampling), four weeks later (second sampling), eight weeks later (third sampling) and 12 weeks later (fourth sampling). Overall, 2.2% of the samples originated from localizations with animal contact taken at the first sampling were positive (Fig. 1). The detection rate increased to values varying between 11.3% and 13.3% during the course of the fattening period. In contrast, the detection rate of Salmonella spp. in samples originated from localizations without continuous animal contact was already 12.6% immediately after disinfection (first sampling). This detection rate of Salmonella spp. in this group of sample sites was constant during the further fattening period.

**Discussion**

The identification of reservoirs of Salmonella spp. in pig herds is supposed to enhance the control of Salmonella infections in fattening pigs and, thus, would help to prevent contamination of pork (STEINBACH and KROELL, 1999). The aim of this study was to localize “hot spots” of Salmonella reservoirs in the course of the fattening period in 12 different farms. Detection rates for Salmonella were not different in various sample sites when time of sampling was not considered. However, detection rate of Salmonella at the first sampling, prior to moving any pigs in, was relatively low in localizations with continuous animal contact, such as pen walls, feeders or nipple drinkers (2.2%). These results indicate that sufficient cleaning and disinfection measurements were taken at spots known to have continuous contact to animals during further fattening period. In contrast, localizations without direct or continuous animal contact such as guide boards, passageways or ventilation or boots showed relatively high detection rates (12.6%) Comparing these figures, a significant difference became obvious (Chi-square: 7.169; P=0.007). It is assumed that cleaning and disinfection of localizations...
without direct or continuous animal contact were often neglected or insufficient due to an underestimation of their relevance. These spots might serve as re-infection sources for the newly arriving animals and could be a reason for circulating infections in the pig herds.

Conclusion
Salmonella detection rates in samples taken in the empty compartment after cleaning and disinfection vary according to the sample site. This indicates a discrepancy in the hygiene measurements at these different localizations. The higher detection rates in localizations without continuous animal contact show a lack of cleaning and disinfection at these spots. Therefore it is essential to improve the hygiene management at these spots in order to prevent Salmonella reservoirs and lower the risk of circulating infections.

References

EFSA, 2006b, Opinion of the Scientific Panel on Biological Hazards on the request from the Commission related to "Risk assessment and mitigation options of Salmonella in pig production. www.efsa.europa.eu, Question No EFSA-Q-2005-019
