Table 2. Sensitivity and specificity of abbreviated scheme as compare to the API 20E for biochemical identification of E. coli. Isolates unidentified by API are not included in analysis.

<table>
<thead>
<tr>
<th>Abbreviated Scheme</th>
<th>Positive</th>
<th>Negative</th>
<th>Gold Standard (API 20E)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PPV=132/132=100%</td>
<td>NPV=7/19=25%</td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>132</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>12</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Sensitivity=132/144 =91.7% Specificity=4/4 =100%

Acknowledgements: The authors wish to acknowledge the cooperation of the pork producers that participated in this project as well as Andy Bowman, Brian Harr, and Sara Weaver.

References:


Isolation of Salmonella enterica in seropositive classified finishing pig herds

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Summary: The aim of this study was to assess the probability of detecting Salmonella from pen faecal samples in seropositive classified finishing pig herds. The study involved 77 herds from Denmark (20), the Netherlands (20), Greece (17) and Germany (20). The serological herd status was determined by the blood- sampling of 50 finishing pigs. Bacteriological sampling was performed by 20 pen faecal samples per herd. Over-all, 47 % of the blood samples had an OD% larger than 10 and 23 % larger than 40. Salmonella was isolated from 135 (9.3 %) pen faecal samples in 32 herds (42 %). Twenty-eight of these herds (87.5 %) had a within-herd seroprevalence larger than 50% at sample cut-off OD%>10. A correlation coefficient of 0.62 was found between the proportion of culture positive- and seropositive samples in a herd at cut-off OD % > 10 and of 0.58 at cut-off OD % > 40. Due to the low sensitivity of culture methods, apparent ‘false positive’ serological results may well represent real infections not detected by bacteriological testing. In this study, there was an increasing probability of recovering Salmonella with increasing within-herd seroprevalence.

Keywords: pig-bacteria, herd-status, serology, bacteriology, epidemiology,
**Introduction:** Determining the *Salmonella*-status of pig herds as part of a monitoring and intervention programme to reduce the contamination of pork is necessary to direct interventions at high prevalence herds. In addition, slaughtering these herds separately from others will minimise cross-contamination during the harvest-phase (Mousing et al, 1997). Culturing faecal samples for *Salmonella* is a useful tool to determine current infections in a pig herd. However, conventional culture methods are labour intensive, time consuming and expensive and may therefore not be practical or economically feasible for routine application. Modern serological techniques have proven to be convenient and cost effective methods for screening for antibodies against *Salmonella*, indicating exposure in pigs (Mousing et al., 1997). To assess the probability of detecting *Salmonella* in seropositive classified pig herds, pen faecal sampling was performed in herds with at least one serological sample over 10 OD %. The investigation was part of an international research programme, entitled “Salmonella in Pork” (FAIR1 CT95-0400) or SALINPORK (Lo Fo Wong and Hald, 2000). This study was performed between August 1996 and July 1998 and involved herds from Germany, Denmark, Greece and the Netherlands.

**Materials and Methods:** A total of 77 pig herds participated from Denmark (n = 20), the Netherlands (n = 20), Greece (n = 17) and Germany (n = 20). Danish and Dutch herds were selected, based on their high seropositive status, while German and Greek herds were not. Due to these selection procedures and small numbers, these herds are not representative for the actual prevalence in these countries. The serological *Salmonella* status of each herd was assessed in a related investigation (Lo Fo Wong and Hald, 2000) by testing 50 blood samples from market weight pigs. Blood samples were analysed with an indirect mix-ELISA (Nielsen et al., 1995; van der Heijden et al., 1998). Samples with an Optical Density Percentage (OD %) larger than 10 were considered seropositive. After the serological status of a herd was assessed, the herd was re-visited and 20 pooled pen faecal samples, of i.e. 5 times 5 grams each, were collected randomly from pens with fattening pigs. Spearman's rank correlation test was used to calculate non-parametric correlation coefficients. The association between the proportion of *Salmonella* isolates from a herd and the within-herd seroprevalence was modelled by linear logistic regression (PROC GENMOD, SAS Institute, 1996) and adjusted for between-country variation and herd-level clustering.

**Results:** A total of 4194 blood samples were collected in 77 herds, of which 1977 (47 %) had an OD % larger than 10 and 985 (23 %) larger than 40. *Salmonella* could be isolated from 135 (9 %) out of a total of 1455 pen faecal samples. These positive samples originated from 32 (42 %) herds. The bacteriological results in this study are presented in detail in Table 1. Over-all, a correlation coefficient of 0.62 (p < 0.0001, Spearman) was found between the proportion of seropositive samples and the proportion of culture positive samples in a herd at cut-off OD % > 10, and of 0.58 (p < 0.0001, Spearman) at cut-off OD % > 40. The correlation between serological and bacteriological results is illustrated in Figure 1. In high seroprevalent herds, the recovery rate was markedly higher.

**Table 1. The proportion positive herds and samples in Germany, Greece, Denmark and the Netherlands and the serotypes isolated from pen faecal samples.**

<table>
<thead>
<tr>
<th></th>
<th>Germany¹ no. herds (%)</th>
<th>Greece¹ no. herds (%)</th>
<th>Denmark² no. herds (%)</th>
<th>Netherlands² no. herds (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prop.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>positive</td>
<td>1/20 (5.0 %)</td>
<td>4/17 (23.5 %)</td>
<td>17/20 (85.0 %)</td>
<td>10/20 (50.0 %)</td>
</tr>
<tr>
<td>Prop.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>positive</td>
<td>5/303 (1.7 %)</td>
<td>4/340 (1.2 %)</td>
<td>95/400 (23.8 %)</td>
<td>31/412 (7.5 %)</td>
</tr>
<tr>
<td>Serotypes (serogroup)</td>
<td>5 Derby (B)</td>
<td>2 Typhimurium (B)</td>
<td>95 Typhimurium (B)</td>
<td>20 Typhimurium (B)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 London (E1)</td>
<td></td>
<td>9 London (E1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 Bredeney (B)</td>
<td></td>
<td>1 Bovismorbificans (C2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1. 1, O:21, nm (L)</td>
</tr>
</tbody>
</table>

¹ herds randomly selected; ² herds selected based on high seroprevalence
The regression equation for the predicted means was:

\[ \text{logit}(y/n) = -4.35 + 3.53 \times P_{\text{finishers}} \]

where: \( y \) = no. of isolates; \( n \) = no. of pen samples; and, \( P_{\text{finishers}} \) = prop. seropositive finishers.

**Discussion:** There was only a moderate correlation between herd serological and bacteriological results in this study. *Salmonella* could not be isolated in a number of seropositive herds. These apparent 'false positive' results can either be caused by cross-reactivity, a low test cut-off value or by false negative reactions in the reference test. The sensitivity of culture methods is generally low. The presence of latent carriers or intermittent shedders in a herd may decrease the sensitivity of the bacteriological sampling method even further. In contrast to culture methods, latent carrier pigs can be identified through the detection of antibodies against *Salmonella*, provided the O-antigens of the serovar are included in the test. Therefore, a 'false positive' result could represent a real infection which was not detected by bacteriological sampling. Serology is a measure of historical exposure, which may or may not correlate closely to the microbiological burden at the time of sampling. However, for screening purposes, serological testing provides an indication of exposure to *Salmonella*, which forms the basis for targeted sampling, intervention and logistic slaughter procedures. In Denmark, serological screening followed by bacteriological follow-up has proven to be a successful approach in the National *Salmonella* Surveillance and Control Programme.

**Conclusions:** There is an increasing probability of recovering *Salmonella* with increasing seropositivity in the mix-ELISA.

**Acknowledgements:** We thank the Commission of the European Communities, Agriculture and Fisheries (FAIR) and the participating institutes for financial support of the SALINPORK-project (FAIR1 CT95-0400).

**References**


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**Pork and the number of human multi-resistant *Salmonella* Typhimurium DT104 cases**

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**Summary:** As part of a revision of the Danish *Salmonella* policy, we estimated the impact of nationally produced pork compared to imported pork on the number of human sporadic domestic cases of multi-resistant *Salmonella* Typhimurium DT104 (MRDT104) in Denmark. We also estimated the number of deaths related to the presumed excess mortality associated with MRDT104. Data on exposure from domestic and imported pork were built into a simple simulation model in @Risk, and Monte Carlo simulations were used. Our results showed that imported pork resulted in 20 times as many human cases as domestic (2 human cases per year), and 1 extra death in 50 years. If the prevalence of MRDT104 in domestic pork increased 5 times, the absolute number of human cases (related to Danish pork) would be 8-11. The excess mortality due to this rise in human cases will be negligible compared to the mortality caused by other Salmonellae.

**Keywords:** food safety, human health, risk assessment, surveillance, trade

**Introduction:** Multi-resistant *Salmonella* Typhimurium DT104 (MRDT104) is of primary interest in many countries because of concern for human health. It has been suggested, that MRDT104 is associated with an excess mortality among humans. In Denmark, an eradication policy was initially carried into effect in the swine sector. This policy, among others, included depopulation of affected swine herds and mandatory bacteriological follow-up in herds with high levels of antibodies against *Salmonella*. MRDT104 spread despite the extensive means taken.

As part of a revision of the Danish *Salmonella* policy, we were interested in estimating the impact of nationally produced pork compared to imported pork on the number of human sporadic domestic cases of MRDT104 occurring in Denmark. We also wanted to estimate the number of deaths to expect because of the presumed excess mortality associated with MRDT104.

**Materials and Methods:** Data on exposure from domestic and imported pork were compared. Exposure was measured as the product between the relative amounts of pork consumed and the prevalence of MRDT104 in domestic and imported pork, respectively. Data describing *Salmonella* prevalence, the prevalence of MRDT104, and the number of human cases covered the time period 1998 to 2002. A simple simulation model was built in @Risk, and Monte Carlo simulation with 10,000 simulations was used. Pert distributions (with minimum, mode, and maximum) were used for all input parameters (Table 1).