Effect of carcass decontamination at pig slaughterhouses on the number of human *Salmonella* cases in Denmark.

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DTU Food  
National Food Institute
Danish project:

“DECONT”: 2005-2009

“Efficacy cost benefit and consumer perception of post harvest carcass decontamination of slaughter pigs”

• Data generation
• Effect of steam, hot water and lactic acid decontamination
• Risk modelling
• Cost effect modelling
• Consumer perception
• Willingness to pay
Background for focus on carcass decontamination of pork in Denmark:

E.C. regulation 853, article 3, 2004 opens up for physical decontamination in EU.

Political wish to approach the low Swedish Salmonella levels in pork.

Exhaustion of the current control programs.

Increased industrial interest for end-point decontamination. A simple (and relative cheap) way to improve food safety compared to herd intervention.

Experience with Hot Water Decontamination of 0,5-1 % of production.

Possible significant impact on food safety.

Could be outbreak protective.

No information on decontamination of pork available from other EU countries.
Concerns about decontamination

- Toxicity of compounds?
- May lead to poor slaughterhygiene?
- Discolouration of meat
- Excessive water consumption (Hot Water Decontamination).
- Consumer acceptance
- May not be installed in small slaughterhouses (Practical/economical reasons)
- Small slaughterhouses – significant suppliers of fresh meat in DK
- Unknown effect on human illnesses
Development of the prevalence of *Salmonella* on swine carcasses 2001-2007
Bacteriological fresh meat surveillance at slaughterhouses

![Graph showing the development of the prevalence of *Salmonella* on swine carcasses from 2001 to 2007.](image)

- **% positive prøver**
- **% positive, moving avg. for 12 month**

**Måned**


Source: Danish Veterinary and Food Administration

Opdateret 03-03-2008
Salmonella source attribution of 1775 registered human cases in Denmark in 2006

Pork associated: 107 (82-138).

- Pork (4.6-7.8%)
- Beef (0.8-2.0%)
- Table eggs (4.9-7.5%)
- Broilers (0.2-1.0%)
- Ducks (0.2-1.3%)
- Imported pork (0.7-2.6%)
- Imported beef (0.7-2.1%)
- Imported chicken (7.4-11.0%)
- Imported turkey (4.1-6.6%)
- Travel (mean: 25%)
- Unknown (33.5-39.4%)
- Outbreak, source unknown (5.9%)
- Imported ducks (0.3-1.2%)
Bacteria hide themselves – a challenge to decontamination

**Figure 1:** CSLM of hair follicle with green fluorescent *Yersinia enterocolitica* moving into the cavity by capillary force. X10

Source: Rikke Krag, KU/ DTU

Decontamination methods investigated:

- Steam ultra sound
- Hot Water Treatment
- Lactid acid
Figure 2
Pork skin inoculated with gfp-tagged *Yersinia enterocolitica* and decontaminated with Sono Steam for 2 sec. After decontamination few bacteria are identified and mainly in deeper tissue structures.
Steam ultrasound - SonoSteam®

[Diagram showing the process of steam ultrasound]

[Caption: Oscillating water molecules]

[Caption: Microorganisms]
Effect of Sonosteam treatment on *Salmonella Typhimurium* seeded \((10^7\text{cfu/cm}^2)\) on skin and meat side of jaw samples \((n=6)\) ± SD

<table>
<thead>
<tr>
<th>Treatment time (seconds)</th>
<th>Skin</th>
<th>Meat</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>0.57</td>
<td>0.44</td>
</tr>
<tr>
<td>1.0</td>
<td>2.05</td>
<td>1.23</td>
</tr>
<tr>
<td>1.5</td>
<td>2.33</td>
<td>1.52</td>
</tr>
<tr>
<td>2.0</td>
<td>3.21</td>
<td>2.03</td>
</tr>
</tbody>
</table>
Hot water Decontamination
80°C for 15 seconds

Almost all level III herds and all S. Typhimurium DT104 infected herds
Prevalence of Salmonella on carcasses after Hot Water Decontamination

Almost all carcasses from Salmonella level III herds and S. Typhimurium DT104 herds are Hot Water Treated in Denmark = 0,5-1 % of production

<table>
<thead>
<tr>
<th>Serological level</th>
<th>Salmonella prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- HWT</td>
</tr>
<tr>
<td>I</td>
<td>1,76</td>
</tr>
<tr>
<td>II</td>
<td>3,84</td>
</tr>
<tr>
<td>III</td>
<td>5,07</td>
</tr>
</tbody>
</table>

Reduction in prevalence : 40-50 fold
Risk model

Modelling carcass contamination before and after decontamination

Modelling no. salmonella bacteria per serving

Dose response modelling and adjusting to the Danish source attribution model
Risk modelling

Exposure model – salmonella on carcasses

Amount of faeces on carcass
N= 1920

Salmonella bacteria in faeces
N=1440

[Graph showing distribution for Salm_carcass/G6 with mean = 36.16174, 5% at X <= 23.4, 95% at X <= 63.47]
Salmonella per serving

- Salmonella per carcass (75 kg)
- Salmonella per serving (200 g)
- Reduction factor for food preparation
- Salmonella per prepared serving
Beta-Poisson Dose-response

\[ P_{\text{inf}} = 1 - (1 + \text{Dose}/\beta)^{-\alpha} \quad (\alpha, \beta = 0.132, 51.5, \text{FAO/WHO 2008}) \]
## Predicting no. of cases from Relative Risk

<table>
<thead>
<tr>
<th>Method</th>
<th>Relative Risk</th>
<th>No. of cases/year 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>No decontamination</td>
<td>1</td>
<td>107</td>
</tr>
<tr>
<td>Hot water 80°C 5 secs</td>
<td>0.08</td>
<td>9</td>
</tr>
<tr>
<td>Hot water 80°C 15 secs</td>
<td>0.05</td>
<td>5</td>
</tr>
<tr>
<td>Hot water 80°C 15 secs 1% lactic acid</td>
<td>0.01</td>
<td>1</td>
</tr>
<tr>
<td>Hot water 55°C 2.5% lactic acid</td>
<td>0.12</td>
<td>13</td>
</tr>
</tbody>
</table>
Factors providing uncertainty to the estimate

Methodology and tissue associated effect of decontamination methods

Temperature abuse/growth
Dessication/reduction
Cross contamination
Under cooking
Ready to eat sources
Relative Risk for Human Salmonellosis

<table>
<thead>
<tr>
<th>Abattoir</th>
<th>RR</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>3.57</td>
</tr>
<tr>
<td>B</td>
<td>2.48</td>
</tr>
<tr>
<td>A</td>
<td>2.17</td>
</tr>
<tr>
<td>D</td>
<td>1.24</td>
</tr>
<tr>
<td>C</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Mean = 36.16174
X ≤ 23.45%
X ≤ 53.47%
Perception of different risk reductions strategies

To solve the problem with pathogenic bacteria in meat it is OK to:

- Freeze the meat
- Treat with steam
- Boil the meat in water
- Irrigate with hot water
- Marinate meat with soy sauce
- Irrigate the meat with chlorous comp...

Definitely
2
3
4
Not at all

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DTU Food, Technical University of Denmark

Sanco workshop February 2009
Conclusion

Decontamination methods available or under development

Potential significant impact on food safety, estimated to 10-100 fold decrease in human illness if all meat is treated.

Slaughter house hygiene have significant effect on human risk

Retail and consumer hygiene level influence the effect of carcass decontamination

Outbreak not included in model

Decontamination may be used for specific purposes (high risk carcasses, meat for fermented products)
Thank you for your attention
Table 2. Cost data for different decontamination technologies

<table>
<thead>
<tr>
<th></th>
<th>Hot water slaughtering</th>
<th>Steam ultrasound</th>
<th>Lactic acid 2.5% 55 °C in 120 seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcass per year (1000)</td>
<td>740</td>
<td>740</td>
<td>740</td>
</tr>
<tr>
<td>Investment (1000 DKK#)</td>
<td>342</td>
<td>604</td>
<td>12</td>
</tr>
<tr>
<td>Capital cost</td>
<td>55</td>
<td>97</td>
<td>2</td>
</tr>
<tr>
<td>Energy and water cost</td>
<td>85</td>
<td>27</td>
<td>3</td>
</tr>
<tr>
<td>Labour cost</td>
<td>25</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Other variable costs</td>
<td>25</td>
<td>27</td>
<td>5</td>
</tr>
<tr>
<td>Total cost</td>
<td>191</td>
<td>150</td>
<td>20</td>
</tr>
<tr>
<td>Costs per carcass</td>
<td>0.26</td>
<td>0.20</td>
<td>0.03</td>
</tr>
</tbody>
</table>

# Danish Meat Institute (hot water), FORCE Technology (steam ultrasound), SFK Systems, (steam vacuum) and Spraying System (lactic acid spray)
Major foodborne human infections in Denmark 1988-2006

Estimated number of human cases per 100,000

Source: Danish Zoonoses Centre, DTU National Food Institute
Prevalence of Salmonella positive carcasses for herds in Level I, II, and III with and without Hot water Dewcontamination (HWD)

<table>
<thead>
<tr>
<th></th>
<th>Level I</th>
<th>Level II</th>
<th>Level III</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Routine&quot; slaughter, no HWD</td>
<td>1.76</td>
<td>3.84</td>
<td>5.07</td>
</tr>
<tr>
<td>(Number of pools)</td>
<td>(5130)</td>
<td>(560)</td>
<td>(6000**)</td>
</tr>
<tr>
<td>Sanitary slaughter with HWD</td>
<td>0.04</td>
<td>0.31</td>
<td>0.11</td>
</tr>
<tr>
<td>(Number of pools)</td>
<td>(919)</td>
<td>(288)</td>
<td>(621)</td>
</tr>
</tbody>
</table>

*: adjusted for a sensitivity of 55% due to pooled sampling
**: individual samples

Reduction in prevalence: 40-50 fold.
Structure of model: Patogens on carcasses

Figure 1. Schematic representation of the simulation model. From a.) paired results of the concentration of E. coli in faeces and in carcass swab samples obtained from the same animal, the faecal contamination of the carcass is estimated (i.e cfu/ml in swab ⇒ cfu on 2800 cm² swabbed surface ⇒ cfu on total carcass surface). Combining the estimate with b.) the probability distribution of the number of salmonellas per gram faeces from infected swine, results in an estimated number of salmonellas per carcass. The simulation results are validated through carcass measurements of Salmonella contamination described in c.) a probability distribution of the number of salmonellas per ml from carcass swab samples.
Prevalence of Salmonella positive carcass swabs in selected EU countries

(EFSA Salmonella baseline in slaughter swine, carcass swabs, 2008)

max: 20.0% (95%CI: 10.8;34.0)

13 MS group: 8.3% (95%CI: 6.3;11.0)

Crude estimate of effect if all carcasses are treated:

0,1%  0,2%  0,4%  0,6% after Hot Water Treatment

5%  10%  15%  20% Before Hot Water Treatment
Prevalence of Salmonella positive carcass swabs in selected EU countries

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max: 20.0% (95%CI: 10.8;34.0)

13 MS group: 8.3% (95%CI: 6.3;11.0)
Figure 1a, b and c.
Pork skin inoculated with gfp-tagged *Yersinia enterocolitica* and decontaminated with Sono Steam for 1 sec. After decontamination bacteria are located on skin surfaces and in deeper structures.