Salmonella risk assessment in home-mixed feeds for pigs

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Home-mixing as a risk for *Salmonella* introduction in pig farms

- Few information available
  - Risk factors studies *(Rossel et al, 2006; Vonnahme et al, 2006; Rajić et al, 2007)*
  - Scientific opinion on microbiological risks in feeds *(EFSA, 2008)*
risk of introduction of *Salmonella* to livestock as a result of home-mixing of contaminated ingredients?

“*may be a significant under-recognised risk with home-mixing…*”

- “in some countries strict precautions to minimise contamination of commercial feed but far less control of materials for home-mixing”
- “good storage facilities may be deficient in many situations such that contamination by rodents, wild birds, insects and development of condensation is poorly controlled”
- “lack of heat treatment step → no critical control point”
- “less sophisticated facilities (including mobile equipment) & inferior quality control measures”

“….some protective factors”

- “risk can be mitigated by use of organic acids”
- “bulk buying and prolonged storage of ingredients → risk of contamination events”
Home-mixing as a risk for *Salmonella* introduction in pig farms

**Few information available**

- **Risk factors studies** (Rossel et al, 2006; Vonnahme et al, 2006; Rajić et al, 2007)
- **Scientific opinion on microbiological risk in feeds** (EFSA, 2008)
  - conflicting risk factors and protective factors in home-mixed feed production
  - need for more information

**Assessment study in France**

- **Surveys + analysis** *(n = 419)*
- **Evaluation in pig farms** *(n = 50)*
  - Procedures and equipment
  - Raw material and feeds sampling
% of the pig feed market mixed on-farm
- GB → 43 % (Hazzledine et al, 2011)
- DK → 60 % (Challan-Belval, 2013)
- D → 40 % (Krüsken, 2008)
- F → 40 % (Martin-Houssart, 2007)

market analysis by Nutreco (H. de Wildt, 2013)
- “Home-mixing farmers and integrators are the fastest growing segments in Europe”
- “Compound feed industry in the future will only remain strong in countries where:
  - Farmers make purchase decisions on feed
  - Farmers have relatively poor access to raw materials”
Salmonella risk in feedingstuffs?

- Reports of EU Salmonella monitoring plans
  - % positive findings
  - Positive oil seed meals: 5% → 3%
  - Low occurrence of S. typhimurium & S. enteritidis

![Graph showing the percentage of positive findings for different types of foodstuffs over the years from 2002 to 2012.](image-url)
Results: ingredients sources of French pig farms

Feed materials used by home-mixers

- Average farm
  - 6 compound feeds or more
  - 6 raw materials or more
  - Cereals = 75% of materials
  - 73% of farms = 2 or 3 oil seed meals
  - Purchases = 66% of needs

→ steady flow of raw materials and transports

Frequency of use

Number of oil seed meals

- 26%
- 27%
- 47%

Ingredients:
- Wheat
- Barley
- Triticale
- Sorghum
- Oat
- Dry Corn
- Wet Corn
- Soybean Meal
- Rapeseed meal
- Sunflower meal
- Soy Bean
- Sunflower Seed
- Unsied & Faba
- Bran & Mill
- Phips
- DDGS
- Other
- Oils
- Fibre sources
## Results

### Survey
- 50 home-mixing facilities
- 154 raw materials & 84 mixed feeds
- Analysis in 100 g of sample

### Results

#### Feed materials

<table>
<thead>
<tr>
<th>Feed materials</th>
<th>N</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td>Corn (dry or wet)</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Barley, rye, sorghum, triticale</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>34</td>
<td>1</td>
</tr>
<tr>
<td>Rapeseed meal</td>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>Sunflower meal</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Whey</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Other liquid byproducts</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Bread, biscuits</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Others : soybeans, bran, dry byproducts</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>154</strong></td>
<td><strong>3</strong></td>
</tr>
</tbody>
</table>

#### Mixed feeds

<table>
<thead>
<tr>
<th>Mixed feeds</th>
<th>N</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sow</td>
<td>32</td>
<td>1</td>
</tr>
<tr>
<td>Piglet</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Fattening pig</td>
<td>36</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>84</strong></td>
<td><strong>1</strong></td>
</tr>
</tbody>
</table>

Samples origin
## Controls operated in farms with positive samples

<table>
<thead>
<tr>
<th>Farm</th>
<th>Cereals</th>
<th>Oil seed meals</th>
<th>By-products</th>
<th>Feeds</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td></td>
<td></td>
<td>whey, brewer’s yeast, bread, whey + bread, yoghurt</td>
<td>pig &amp; sow protein complementary feeds</td>
<td>1/7</td>
</tr>
<tr>
<td>AA</td>
<td>triticale, barley</td>
<td>soybean meal, rapeseed meal</td>
<td></td>
<td>fattening pig, gestating sow</td>
<td>1/6</td>
</tr>
<tr>
<td>AB</td>
<td>wheat</td>
<td>soybean meal, rapeseed meal</td>
<td></td>
<td>fattening pig, gestating sow</td>
<td>1/5</td>
</tr>
<tr>
<td>AS</td>
<td>barley</td>
<td>soybean meal, rapeseed meal</td>
<td></td>
<td>gestating sow</td>
<td>1/4</td>
</tr>
</tbody>
</table>

## Serovars
- Farm D: *Salmonella enterica* subsp. *enterica* ser. VENEZIANA
- Farm AA: *Salmonella enterica* subsp. ARIZONAE ser S.IIIa 48 :z4,z23.
- Farm AB: *Salmonella enterica* subsp. *enterica* ser CERRO
- Farm AS: *Salmonella enterica* subsp. *enterica* ser MBANDAKA
Results: Fineness of feeds mixed on-farm

- Particle size analysis of home-mixed feeds

  - Fineness of meal feeds
    - ASAE method -10 sieves

<table>
<thead>
<tr>
<th>Feeds</th>
<th>n</th>
<th>Median diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-weaning phase 2</td>
<td>8</td>
<td>0.65 ± 0.10</td>
</tr>
<tr>
<td>Growing-finishing</td>
<td>28</td>
<td>0.66 ± 0.08</td>
</tr>
<tr>
<td>Sows</td>
<td>16</td>
<td>0.71 ± 0.11</td>
</tr>
</tbody>
</table>

- Classification according home-mixing recommendations

- Favorable effect of coarse grinding
  - Δ stomach survival of Salmonella (Mikkelsen et al, 2004)
  - ↑ pH gradient & ↑ lactobacilli (Bullerman et al, 2012)
  - finely ground pelleted feed Δ pH gradient (Hansen et al, 2003; Moesseler et al, 2010, 2012)
Discussion: Effect of coarse grinding by home-mixers?

- Comparison to studies with effects on S. prevalence


- Papenbrock et al (2005)

- Offenberg (2007) + acids

- Other studies: size not mentioned, wet sieving, roller mills

- No direct effect of fineness of home mixed feeds?
Distribution as meal vs pellets

- Benefits of meal in
  - Risk factors studies (Vonnahme et al, 2006; Rajić et al, 2007; Corrégé et al, 2009)
  - Some experimental studies (Jørgensen et al, 1999; Dahl et al, 1999), but not consistent with (Kjærsgaard et al, 2001; Jørgensen et al, 2003)
- Pellets → neutral mucines ↪ adhesion of Salmonella in intestine (Hedemann et al, 2005; Betscher et al, 2010)

Liquid feeding

- ↩ salmonella in risk factors studies (Dahl et al, 2000; Kranker et al, 2001; Fablet et al, 2003; Lo Fo Wong et al, 2004; Farzan et al, 2006; Corrégé et al, 2009)
- Lactobacilli in liquid distribution systems (Royer et al, 2004)
- CCM, liquid by-products
## Implementation of main biosecurity measures

<table>
<thead>
<tr>
<th>Implementation rate</th>
<th>&lt; 50 %</th>
<th>50 - 80 %</th>
<th>&gt; 80 %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Raw ingredient and feed storages</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw materials out of rodents and birds</td>
<td>Measures against insects</td>
<td>Measures against rodents</td>
<td></td>
</tr>
<tr>
<td>Coverage of storage bins</td>
<td>Cleaning of feed storage</td>
<td>Frequent cleaning of ingredients units</td>
<td></td>
</tr>
<tr>
<td>Birds in building</td>
<td></td>
<td>Mixed feeds out of rodents and birds</td>
<td></td>
</tr>
<tr>
<td><strong>Equipments and process</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Footbath for mixing unit</td>
<td>Grain cleaner</td>
<td>Separation of home-mixing and pig units</td>
<td></td>
</tr>
<tr>
<td>Records of cleanings</td>
<td>Frequent removal of dust</td>
<td>Coverage and grid on reception pit</td>
<td></td>
</tr>
<tr>
<td>Knowledge of Salmonella status</td>
<td>Complete emptying of feed mixer</td>
<td>Frequent cleaning of reception pit</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sampling of feeds</td>
<td>Frequent cleaning of manufacturing unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pets not allowed in units</td>
<td>Cleaning of liquid feeding system</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results: Rodents & birds

- Prevention against rodent and pest infestations

<table>
<thead>
<tr>
<th></th>
<th>implementation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>absence of rodent around the building</td>
<td>62</td>
</tr>
<tr>
<td>prevention against rodents</td>
<td>97</td>
</tr>
<tr>
<td>prevention against insects</td>
<td>87</td>
</tr>
<tr>
<td>pets not allowed in the area</td>
<td>48</td>
</tr>
</tbody>
</table>

- Birds in storage & mixing building

EAAP Annual meeting, S47

Copenhagen, August 28, 2014
Discussion: other studies

Control campaign in Denmark (Danish Food Authority, 2011)

- 17 home-mixing pig herds
  - 9 farms ← imported highly contaminated HP soymeal (including Typhimurium)

- Salmonella analysis of feed materials

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scratch samples in storage and feed line</td>
<td>55</td>
<td>0</td>
</tr>
<tr>
<td>Soybean &amp; rapeseed meals</td>
<td>7</td>
<td>1 (S cubana)</td>
</tr>
<tr>
<td>Home mixed feeds</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Purchased compound feeds</td>
<td>2</td>
<td>1 (S typhimurium)</td>
</tr>
</tbody>
</table>

- serology of meat juices samples
  - only 1 farm ↗ after contaminated soymeal: doubtful ← previous problems

- overall hygiene evaluation
  - 3 farms with unsanitary conditions: rats or pests, leaks in barns, dust, transport equipment ↔ feeds + risk materials
  - others: slight remarks on emptying & cleaning frequency, traceability

‘home-produced feed does not appear to increase the risk’
Cross contamination with herds

- *Salmonella* presence on cattle, pigs, poultry herds → storage & mixing area?
  - Birds, rodents, pets, insects?
  - Milling facility closed to main livestock buildings?
  - Tractors used in the mill and around the farm?

- Contribution of contaminated feed to cycle of infection on farm?

Future research

- Status of feed manufactured on farm: major risk or indicator of general contamination? *(EFSA, 2008)*
- More epidemiological work to evaluate risk factors, ‘gut health’ aspects and protective factors
Risk of transmission of *Salmonella* from home-mixed feeds to pigs seems generally restrained,
- moderate prevalence in feed materials and compound feeds
- dominant serotypes
- meal or coarse meal + liquid feeding → a lower risk

Effective compliance with good practices should reduce the risk of *Salmonella* contamination in pig farms manufacturing their own feed.
Aknowledgements

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