INFLUENCE OF DIETARY ADMINISTRATION OF ORGANIC ACIDS AND  
INCREASED FEED STRUCTURE ON  
SALMONELLA TYPHIMURIUM INFECTION IN PIGS  

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Several epidemiological investigations and reports from advisors practicing in swine herds  
have independent of each other pointed out commercial feed mixes compared to home mixed  
feed and dry feed compared to wet fermented feed to be the most important risk factors for  
increased Salmonella infection levels in Danish slaughter pigs (Dahl (1997), Stege (1997)).  
The significance of these factors in practice is unquestionable, but the effective principle(s)  
responsible for the effect is unknown. We hypothesized the effect to be due to either fine  
grinding and/or pelleting of commercial mixes resp. acidification and/or increase of yeast and  
lactobacilli in wet fermented feed.  
The result of in-herd trials of commercial mixes vs. home mixed feed and addition of organic  
acids (formic acid in water or a commercial mixed organic acids/salt product for in-feed  
administration) for control of S. Typhimurium infection in growers and finishers is presented.  

MATERIALS AND METHODS  

Three trials were carried out. Trial 1 was carried out in one herd, trial 2 and 3 in another. Both  
herds were farrow-to-finish productions with varying degree of infection with S. Typhimurium  
in finishers units for several years. Weaners, growers and finishers units were managed all in-all  
out, and careful cleaning and disinfection was carried out between batches. Pigs newly  
introduced to finishers units were culture negative for Salmonella as well as seronegative.  

Trial 1:  

In a finishing unit with fully slatted floor and open pen separations 5/10 pigs in each of 20  
pens were selected for sampling (a total of 100 pigs). Pigs were fed either feed C: coarse grinded  
(rolled) grain and pelleted concentrate, or feed F: finely ground, pelleted compound feed (10  
pens each, randomly selected). Main constituents were wheat (31%), barley (31%), soy bean  
meal (24%) and wheat bran (8%). Protein content approx. 19.7%. Both feeds were added 20 ppm  
tylosinphosate, and were fed ad libitum as dry feed. One % formic acid was added to the water  
supply in pens on one side of the aisle. The experimental set-up did not allow a statistical  
evaluation of the effect of formic acid. Blood was collected from the pigs at introduction into  
finishers unit (day 0), day 28, 45, 60, 66, 74 and immediately before slaughter day 81. One  
pooled faecal sample from each pen was collected day 60 and individual faecal samples were  
collected at slaughter. Characterization and quantification of intestinal flora and gastro-intestinal  
content of organic acids was performed on pigs from repetitions of this experiment under slightly  
different conditions.  

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**Trial 2:**

Three finishers units (8 pens each, 30 pigs per pen) were included in the trial. The age of the pigs was equal within a unit but differed between units. All units were culture positive for S. Typhimurium prior to the experiment. In each unit 4 ppm of a commercial organic acid product (Bact-a-cid = formic acid, propionic acid and corresponding ammonium salts) was added to the feed in half of the pens (randomly selected) from day 0 to slaughter (35, 50 and 64 days respectively). Day 0, 14 and immediately before slaughter (day 35, 50 or 64) blood samples and individual faecal samples were collected from 6 marked pigs per pen.

**Trial 3:**

Nine finishers units (8 pens in 8 units, 4 pens in one unit) were included. In each unit 4 ppm Bact-a-cid was added to the feed in half of the pens (randomly selected) for the entire finishing period. One unit experienced a slurry flooding during the experiment. Immediately prior to slaughter blood samples were collected from 6 pigs in each pen.

**Analyses:**

Serum was examined for antibodies to *Salmonella* in a mix-ELISA (Nielsen et al., 1995). The average OD% and the proportion of seropositive pigs were calculated (scientific cut-off = 10 OD%, high responders = 40 OD%). Faecal samples (individual as well as pooled from pens) were submitted to qualitative examination for *Salmonella* by non-selective pre-enrichment, selective enrichment, biochemical identification and O-serotyping.

**RESULTS**

![Graph](image1)

**Figure 1. Serological reaction to *Salmonella* in each group in Trial 1.**

**Trial 1:**

The over-all serological course differed significantly between feed C and F (p=0.021) (Figure 1). The experimental design did not allow statistical evaluation of the effect of formic acid in water, but in these groups % seropositive were below corresponding groups without formic acid. Only one faecal sample was culture positive for *S. Typhimurium* day 60, no samples were culture positive at slaughter. Feed C compared to feed F increased the microbial activity, the counts of anaerobe bact., lactic acid bacteria and yeast and reduced coliforms, lactose-neg. *enterobacteriaceae* and *enterococci*. pH was not affected but changes in organic acids reflected the bacterial changes.

**Trial 2:**

From day 0 to 14 shedding of *Salmonella* was reduced from 66.7% to 34.7% in the Bact-a-cid group and from 52.0% to 26.4% in the control group. At slaughter the shedding was further
reduced to 14.5% of the Bact-a-cid treated pigs and 10.4% of the control pigs. The differences between groups was non-significant (p(day 14)=0.75, p(slaughter)=0.26). Between day 0 and day 14 the average serological response increased from 49 OD% to 67 OD% in the Bact-a-cid group and from 45 OD% to 56 OD% in the control group. The average response decreased to 34 OD% in the Bact-a-cid group and 27 OD% in the control group between day 14 and slaughter. The differences between groups were non-significant (p(day 14) = 0.14, p(slaughter) = 0.42).

**Trial 3.**

A significant difference between experimental groups (+/- Bact-a-cid) was detected for scientific-cut-off responders as well as for high responders if the slurry-flooded unit was excluded from calculations. If not, only the proportion of high responders differed significantly (table 1)(mixed models with date and pen as random effects). Variation between units (supposed due to different infection levels) influenced the serological response even more than treatment.

**Table 1. Seroreaction in pigs in trial 3 (no. seropositive pigs/no. sampled pigs)**

<table>
<thead>
<tr>
<th>Cut-off (OD%)</th>
<th>Slurry-flooded unit incl.</th>
<th>Bact-a-cid treated</th>
<th>Control</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>yes</td>
<td>61/204</td>
<td>74/202</td>
<td>0.18</td>
</tr>
<tr>
<td>10</td>
<td>no</td>
<td>37/180</td>
<td>53/178</td>
<td>0.03</td>
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<td>40</td>
<td>yes</td>
<td>22/204</td>
<td>47/202</td>
<td>0.02</td>
</tr>
<tr>
<td>40</td>
<td>no</td>
<td>12/180</td>
<td>31/202</td>
<td>0.02</td>
</tr>
</tbody>
</table>

**DISCUSSION AND CONCLUSION**

Fine feed structure/pelleting compared to coarse grinding increased the serological response to *Salmonella* and changed the gastro-intestinal microbiology and organic acids for the supposed benefit of a “healthy” micro-environment. An effect on seroreaction to *Salmonella* of addition of organic acids to feed was demonstrated. This effect was not shown if acids were added for a limited period to culture positive pigs, and the effect on the proportion of low-responders was eliminated by slurry-flooding. The effect of organic acids in feed might be underestimated, as only half of the pens were treated.

**REFERENCES**

