A review on Salmonella inhibition in poultry and pigs through the use of diformates

14th INTERNATIONAL FEED TECHNOLOGY SYMPOSIUM
„FEED TECHNOLOGY, QUALITY AND SAFETY“
Novi Sad 21th October

Dr. Peter Theobald
ADDCON, Bonn
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• Impact of pathogenic bacteria
• Diformates basics
• Diformates results
  • Microbiology
  • Campylobacter
  • Salmonella
• Conclusion
Pathogenic bacteria – a serious problem!

- Global incidence of food borne diseases (2005):
  1.8 million people died from diarrhoeal diseases
- USA – each year: 76 million cases of food borne diseases; 325,000 hospitalizations; 5,000 deaths
- Salmonellosis in the USA (1994) affected 224,000 people
- Food contamination with pathogens creates enormous social and economic costs; in the USA 1997 estimated as 35 billion USD annually
- Annual costs of Salmonella to UK economy are more than 46 Mio £ and 2.8 billion € across the EU (2001)
- Newest figures from the EU (2007): 152,000 people affected by Salmonella

Dennis 2004; WHO, 2005; World Poultry 2009
Salmonella is an ubiquitary occurring bacteria and it’s often found in the digestive track of animals (mammals, bird, reptiles, insects)

- Genus name from Daniel Salmon, who first identified it (1885)
- Rod shaped, fakultatively anaerobic
- **gram-negativ**
- *Enterobacteriaceae* (intestinal bacteria)
  - Salmonella (Genus)
    - enterica (species)
    - serovar (over 2500 serovars)
Salmonella - background

Salmonella, where did they come from?

- birds
- insects
- rodents
- feed
- water
- pets
- visitors

ADDCON
• Impact of pathogenic bacteria

• **Diformates basics**

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Mode of action - pigs

Feed
- potassium diformate

Feed

Stomach
- pH 2.5-4.5
- partial dissociation to Formic acid + potassium formate
- pH reduction

Small intestine
- 85% of dietary formate enters the duodenum
- Dissociation of potassium formate to formic acid and potassium.
- Decreases pH by 0.3 to 0.5 units
- Formic acid acts as antimicrobial

Formic acid is broken down to $H^+$ and $CO_2$ and incorporated into bacteria
Recovery of FORMI in the gut

85% of FA passes the stomach and reaches the small intestine → “bypass-effect” without coating

Mroz et al., 2000
**Mode of action - poultry**

- **Colon:**
  - promotes the natural microflora
  - reduces harmful bacteria

- **Crop:**
  - decreases pH
  - reduces harmful bacteria

- **Stomach:**
  - decreases pH
  - activates pepsin
  - optimizes protein digestion

- **Small intestine:**
  - reduces harmful bacteria
  - improves beneficial bacteria flora
  - improves secretion of digestive juices
  - optimizes nutrient digestibility

- **Faeces:**
  - reduces harmful bacteria - lower risk of cross infections
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Effect of FORMI NDF on gut microflora

Broiler trial in Spain; effect on intestine bacteria – 1750 broiler in 3 treatments

Log-count of bacteria in the intestine (CFU/g):

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>FORMI NDF 0.6%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterobacteria</td>
<td>$10^7$</td>
<td>$10^5$</td>
</tr>
<tr>
<td>Lactobacilli</td>
<td>$10^7$</td>
<td>$10^8$</td>
</tr>
<tr>
<td>Bifidobacteria</td>
<td>$10^5$</td>
<td>$10^6$</td>
</tr>
</tbody>
</table>

Improvement of beneficial gut microflora!

Lückstädt and Theobald, 2009
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Broiler trial in Spain; effect against pathogen bacteria – 1750 broiler in 3 treatments

Number of positive samples (%):

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>FORMI NDF 0.3%</th>
<th>FORMI NDF 0.6%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop (microbiol.)</td>
<td>60</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Intestine (microbiol.)</td>
<td>80</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Meat (serol.)</td>
<td>80</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Clear effect of FORMI NDF against Campylobacter!

Lückstädt and Theobald, 2009
• Impact of pathogenic bacteria
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  • Campylobacter
  • **Salmonella**
• Conclusion
Effect of FORMI NDF against Salmonella

Broiler trial in Spain; effect against pathogen bacteria – 1750 broiler in 3 treatments

Number of positive samples (%):

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Control</th>
<th>FORMI NDF 0.3%</th>
<th>FORMI NDF 0.6%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop (microbiol.)</td>
<td>20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Intestine (microbiol.)</td>
<td>20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Faeces (microbiol.)</td>
<td>25</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Meat (serol.)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Significant effect of FORMI NDF against Salmonella!

Lückstädt and Theobald, 2009
Excretion of Salmonella in pigs (10 replicates per treatment)

Positive fecal samples (%)

Days after infection

Vet. University Hannover, 1999
FORMI reduces the prevalence of *Salmonella* in *Salmonella* positive herds I

**Prevalence of Salmonella**
- Level 3, high
- Level 2, medium
- Level 1, low

**Months before and after addition of 0.6% FORMI**

-3 -2 -1 0 1 2 3 4 5

**No. of herds**

- 15
- 10
- 5
- 0

**Recommendation:**
*Use of 0.6% FORMI for 6-8 weeks before slaughtering*

Olesen 1999, KFK Denmark
FORMI reduces the prevalence of *Salmonella* in *Salmonella* positive herds II

Bacteriological and serological prevalence of *Salmonella* spp. in finishing pigs on 7 farms highly infected with *Salmonella* spp. - before and after implementation of control measures (FORMI at 6 kg/t) for approximately 24 months (in percent)

<table>
<thead>
<tr>
<th></th>
<th>Salmonella status:</th>
<th>Before FORMI</th>
<th>Salmonella status:</th>
<th>After FORMI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bacteriological prevalence</td>
<td>Serological prevalence</td>
<td>Bacteriological prevalence</td>
<td>Serological prevalence</td>
</tr>
<tr>
<td>Farm F</td>
<td>100</td>
<td>88</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>Farm G</td>
<td>77</td>
<td>63</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Farm H</td>
<td>32</td>
<td>17</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Farm I</td>
<td>71</td>
<td>54</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Farm J</td>
<td>15</td>
<td>42</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Farm K</td>
<td>37</td>
<td>96</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>Farm L</td>
<td>4</td>
<td>96</td>
<td>0</td>
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</tr>
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</table>

Lynch et al. (Teagasc), 2007
2 Trials (T1 und T2) were carried out:

- **T1**
  - Control: finely ground, pelleted
  - Treatment: coarsely ground, pelleted + 1.2% KDF

- **T2**
  - Control: coarsely ground, pelleted
  - Treatment: coarsely ground, pelleted + 1.2% KDF

- Oral Infection with *Salmonella derby*
- Swab sample for analysis of Salmonella

Vet. University Hannover, Germany, 2003
Coarse feed + KDF significantly (P<0.05) reduces Salmonella compared to finely ground feed (T1);

However KDF can still improve coarse feed („on top“-effect of KDF) - (T2)

Vet. University Hannover, Germany, 2003
Salmonella, feed structure + KDF – duration of Salmonella excretion

<table>
<thead>
<tr>
<th>Feed Structure</th>
<th>T1 Duration (in days)</th>
<th>T2 Duration (in days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>1.2% KDF</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Fine + KDF</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>Coarse + KDF</td>
<td>8</td>
<td>4</td>
</tr>
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*KDF reduces the excretion period significantly (P<0.05), in both trials (also compared to coarse feed alone) – Data are backed by newer research from the same institute (Visscher 2007)*

Vet. University Hannover, Germany, 2003
KDF reduces the prevalence of *Salmonella* in a *Salmonella* positive herd (UK)

**T1: Annually; T2: Quarterly**

*KDF (0.6%) reduced the presence of Salmonella by 46% in pigs (from 38 kg till slaughter) – and reduced furthermore the mortality from 4.25% to 2.53% (rolling average)*

Dennis and Blanchard, 2004
KDF reduces the prevalence of *Salmonella* in *Salmonella* positive herds (Ireland)

Bacteriological and serological prevalence of *Salmonella* spp. in finishing pigs on 7 farms highly infected with *Salmonella* spp. - before and after implementation of control measures (KDF at 6 kg/t) for approximately 24 months (in percent)

<table>
<thead>
<tr>
<th>Farm</th>
<th>Salmonella status:</th>
<th>Before KDF</th>
<th>Salmonella status:</th>
<th>After KDF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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Lynch et al. (Teagasc), 2007
KDF reduces the prevalence of *Salmonella* in *Salmonella* positive herds (France)

Serological prevalence of *Salmonella* spp. in 5 commercial farms (fattening pigs) highly infected with *Salmonella* spp. - before and after implementation of control measures (KDF at 6 kg/t) during a period of 7 months (in percent)

<table>
<thead>
<tr>
<th></th>
<th>Before KDF</th>
<th>During KDF</th>
<th>After KDF</th>
<th>P-level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm 1</td>
<td>25.7</td>
<td>8.0</td>
<td>27.3</td>
<td>0.001</td>
</tr>
<tr>
<td>Farm 2</td>
<td>18.7</td>
<td>6.2</td>
<td>2.3</td>
<td>0.001</td>
</tr>
<tr>
<td>Farm 3</td>
<td>53.7</td>
<td>15.8</td>
<td>7.6</td>
<td>0.0001</td>
</tr>
<tr>
<td>Farm 4</td>
<td>21.9</td>
<td>17.1</td>
<td>20.0</td>
<td>n.s.</td>
</tr>
<tr>
<td>Farm 5</td>
<td>40.8</td>
<td>29.2</td>
<td>1.9</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Correge et al. (IFIP – Institut du porc), 2010
Conclusion

- High efficiency → independently proven
- Large scale commercial trials show practical relevance
- Governmental studies
- Easy and safe to handle
  - Non-corrosive

Safe for humans and animals
Efficient action
Profitable for farmers
FORMI® NDF

The quality enhancer!

Patented growth promoter!

Thank you for your attention!