Dietary *Bacillus subtilis* enhances disease resistance and intestinal health of weaned pigs

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**Introduction**

- Enterotoxigenic *Escherichia coli* (ETEC) is the most common pathotype that causes diarrhea in post-weaning piglets.
- Supplementation of *Bacillus* spp. probiotics reduces incidence of diarrhea and improves growth performance of post-weaning pigs (Bhandari et al., 2008; Hu et al., 2014).
- Probiotics reduced incidence of diarrhea, improved gut barrier integrity, and reduced systemic inflammation of weaned pigs (Kim et al., 2019).

**Objective**

- To investigate the effects of supplementation of *Bacillus* spp. probiotics on the growth performance, diarrhea, and intestinal health of weaned pigs experimentally infected with an enterotoxigenic F18 *E. coli*

**Materials and Methods**

- **Animals**: 48 weanling pigs (21 day, 6.17 ± 0.36 kg)
- **F18 *E. coli* challenge**
  - Enterotoxigenic F18 *E. coli* (LT, STb, SLT-2)
  - Oral inoculation, 10⁶ cfu/dose with 3 doses
- **Experimental design**
  - Randomized Complete Block Design
  - Blocking factors: body weight x gender
  - Experimental period: 28 days, 7-day adaptation and 21-day after first *E. coli* inoculation
- **Dietary treatments**: 12 pigs/treatment
  - Nursery basal diet without *E. coli* challenge (NC)
  - Nursery basal diet with *E. coli* challenge (PC)
  - PC + 50 mg/kg carbadox (AGP)
  - PC + 500 mg/kg *Bacillus* spp. (PRO)
- **Data collection**
  - Growth performance: body weight, average daily gain, average daily feed intake, Gain:Feed
  - β-hemolytic coliforms in feces: d 0 before inoculation and d 3, 7, 14, and 21 post-inoculation (PI)
  - Daily diarrhea score: ranging from 1 to 5 (1, normal feces and 5, watery diarrhea)
  - Jejunal mucosa: mRNA expression of tight junction proteins [claudin 1 (*CLDN1*), Occludin (*OCLN*), Zonula occludens-1 (*ZO1*), mucin 2 (*MUC2*)]
  - Ileal mucosa: mRNA expression of inflammatory mediators [*IL1B, IL6*, TNFA, cyclooxygenase 2 (*PTGS2*)]
- **Data analysis**
  - PROC MIXED of SAS
  - Diet as the main effect and blocks as random effects
  - Experimental unit: pig

**Results**

**Table 1. Growth performance of weaned pigs**

<table>
<thead>
<tr>
<th>Item</th>
<th>NC</th>
<th>PC</th>
<th>AGP</th>
<th>PRO</th>
<th>SEM</th>
<th>P-value</th>
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</thead>
<tbody>
<tr>
<td>Body weight, kg</td>
<td>d 0 PI</td>
<td>7.03</td>
<td>7.17</td>
<td>7.28</td>
<td>7.04</td>
<td>0.43</td>
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<tr>
<td></td>
<td>d 7 PI</td>
<td>8.78</td>
<td>8.53</td>
<td>9.80</td>
<td>8.56</td>
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<tr>
<td></td>
<td>d 14 PI</td>
<td>12.55</td>
<td>10.56</td>
<td>13.84</td>
<td>12.07</td>
<td>0.70</td>
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<tr>
<td></td>
<td>d 21 PI</td>
<td>17.23</td>
<td>13.69</td>
<td>18.79</td>
<td>16.46</td>
<td>0.99</td>
</tr>
<tr>
<td>Average daily gain</td>
<td>d 0 to 7 PI</td>
<td>250a</td>
<td>212ab</td>
<td>359b</td>
<td>218b</td>
<td>28.5</td>
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<tr>
<td></td>
<td>d 7 to 14 PI</td>
<td>549ab</td>
<td>459b</td>
<td>594a</td>
<td>501ab</td>
<td>52.7</td>
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<tr>
<td></td>
<td>d 14 to 21 PI</td>
<td>668b</td>
<td>466b</td>
<td>718b</td>
<td>628a</td>
<td>44.2</td>
</tr>
<tr>
<td></td>
<td>d 0 to 21 PI</td>
<td>486ab</td>
<td>347c</td>
<td>558a</td>
<td>449b</td>
<td>36.0</td>
</tr>
<tr>
<td>Average daily feed intake, g</td>
<td>d 0 to 7 PI</td>
<td>374a</td>
<td>435ab</td>
<td>497a</td>
<td>403b</td>
<td>22.6</td>
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<tr>
<td></td>
<td>d 7 to 14 PI</td>
<td>746b</td>
<td>687b</td>
<td>895b</td>
<td>751ab</td>
<td>66.4</td>
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<tr>
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<td>d 14 to 21 PI</td>
<td>1,070b</td>
<td>860b</td>
<td>1,306a</td>
<td>1,029b</td>
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<td>d 0 to 21 PI</td>
<td>730b</td>
<td>647b</td>
<td>899a</td>
<td>728b</td>
<td>57.5</td>
</tr>
</tbody>
</table>

**Figure 1. Frequency of diarrhea**

- Frequency of diarrhea ≤ 4
- Frequency of diarrhea ≥ 4

**Figure 2. % of β-hemolytic coliforms in feces**

- % of β-hemolytic coliforms in feces: Score ≥ 4

**Figure 3. Tight junction proteins**

- Relative mRNA abundance

**Figure 4. Inflammatory mediators**

- Relative mRNA abundance

**Conclusions**

- Supplementation of *Bacillus subtilis* in pig feed
  - Improved growth performance and disease resistance
  - Alleviated diarrhea, reduced intestinal inflammation, and enhanced gut barrier function

**References**


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