Evaluation of a microbially-converted soybean meal as a substitute for fishmeal in nursery pig diets

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Importance of high quality ingredients for nursery pigs

• Physiological need
  – Digestive enzyme development (starch, fat)
  – Developing immune system
  – Low feed intake
  – High growth rate potential
Immunological Resistance

Age (weeks)

colostrum

pigs immune system

Enzyme Activity

Age (weeks)
Influence of Growth During the First Week Post Weaning

Compensatory growth unlikely to make up for slow growth in first week.

Weight Advantage, lb vs Day Postweaning:
- 0 - .33 lb/d
- .33 - .50 lb/d
- > .50 lb/d

Source: Tokach et al., 1992
Fishmeal and nursery pigs

• Early weaning was facilitated by the use of nutrient dense, high quality protein sources
  – Fishmeal
    • 65% protein, 4.5% Lys, few anti-nutritional factors or fiber
  – Recommend 5 – 7.5% inclusion for first 7d
    • dependent on herd disease status to optimize gains and feed costs

Stoner et al., 1990; Bergström et al., 1997
Increasing demand for fishmeal

Plasma proteins

• Positives
  – High quality protein source with complementary AA profile
  – Stimulates feed intake
  – Reduces intestinal immune activation, promotes gut health and restoration

• Negatives
  – Cost

Hansen et al., 1993; Bergström et al., 1997; Zhang et al., 2016
Soybean meal conundrum

• Positives
  – Economical relative to other quality protein sources
  – Complementary AA profile to cereal grains
  – Readily available

• Negatives
  – Anti-nutritional factors
    • Trypsin inhibitor, P34 protein, lectins, β-mannans
  – Tolerance must be developed = immune activation
Processed SBM

- Bioprocessing or fermentation of SBM
  - Reduces anti-nutritional factors
  - Some degradation of antigenic proteins
  - Retains complementary AA profile
  - Improved digestibility
  - Cost-effective relative to fishmeal

Song et al., 2010; Sinn et al., 2016
MEPRO - objective

• Compare MEPRO to FM in relation to:
  – AA digestibility and age
  – Nursery pig performance
  – Intestinal health
  – In combination with dietary acidifier
Study 1 – animals and diets

• Digestibility
  – 6 ileal cannulated pigs (65 lbs); 37 nursery pigs (22 lbs)

• Performance and gut health
  – 336 weaned pigs (13.4 ± 1.8 lbs, 21 d of age); 8 pens/diet; 5 wks

<table>
<thead>
<tr>
<th>Item, %</th>
<th>Control</th>
<th>+FM</th>
<th>+MEPRO</th>
<th>Control</th>
<th>+FM</th>
<th>MEPRO</th>
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<td>40</td>
<td>39</td>
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<td>Conventional SBM</td>
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<td>41</td>
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<td>7.5</td>
<td>7.5</td>
<td></td>
<td>5</td>
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<td></td>
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</table>

ME = 1,523 kcal/lb; SID Lys = 1.35%

Sinn et al., 2016
Study 1 - observations

• Weekly BW and feed disappearance
• Daily diarrhea assessment (d 0 – 14)
• Intestinal tissue collection (d 7 and 14)
  – Inflammatory cells, proliferation marker, digestive enzyme activity, morphology, pH
## Standard ileal digestibility

<table>
<thead>
<tr>
<th>AA</th>
<th>65 lbs</th>
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<th>22 lbs</th>
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<td></td>
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<td>MEPRO</td>
<td>SEM</td>
<td>FM</td>
<td>MEPRO</td>
<td>SEM</td>
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<tr>
<td>Lysine</td>
<td>93.8</td>
<td>88.8</td>
<td>0.62</td>
<td>82.0</td>
<td>85.6</td>
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<tr>
<td>Methionine</td>
<td>93.8</td>
<td>91.0</td>
<td>0.58</td>
<td>76.7</td>
<td>87.0</td>
<td>2.9</td>
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<tr>
<td>Threonine</td>
<td>92.7</td>
<td>88.1</td>
<td>0.89</td>
<td>79.3</td>
<td>77.8</td>
<td>2.7</td>
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<tr>
<td>Leucine</td>
<td>95.1</td>
<td>91.6</td>
<td>0.68</td>
<td>85.1</td>
<td>83.3</td>
<td>1.9</td>
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<tr>
<td>Isoleucine</td>
<td>94.8</td>
<td>91.0</td>
<td>0.70</td>
<td>84.2</td>
<td>83.1</td>
<td>2.0</td>
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<td>Valine</td>
<td>92.6</td>
<td>90.4</td>
<td>0.77</td>
<td>81.6</td>
<td>82.5</td>
<td>2.1</td>
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<tr>
<td>Phenylalanine</td>
<td>92.5</td>
<td>90.9</td>
<td>0.66</td>
<td>81.2</td>
<td>83.1</td>
<td>2.4</td>
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<tr>
<td>Histidine</td>
<td>92.0</td>
<td>89.6</td>
<td>0.89</td>
<td>75.7</td>
<td>80.7</td>
<td>2.5</td>
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## Growth performance

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>FM</th>
<th>MEPRO</th>
<th>Control +A</th>
<th>FM +A</th>
<th>MEPRO +A</th>
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<tbody>
<tr>
<td><strong>ADG, lbs/d</strong></td>
<td></td>
<td></td>
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<tr>
<td>0 – 7 d</td>
<td>0.11</td>
<td>0.13</td>
<td>0.07</td>
<td>0.04</td>
<td>0.11</td>
<td>0.13</td>
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<tr>
<td>8 – 21 d</td>
<td>0.73</td>
<td>0.75</td>
<td>0.75</td>
<td>0.79</td>
<td>0.73</td>
<td>0.77</td>
</tr>
<tr>
<td>22 – 35 d</td>
<td>1.54</td>
<td>1.72</td>
<td>1.58</td>
<td>1.65</td>
<td>1.65</td>
<td>1.58</td>
</tr>
<tr>
<td><strong>ADF, lbs/d</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 – 7 d</td>
<td>0.24</td>
<td>0.24</td>
<td>0.24</td>
<td>0.24</td>
<td>0.24</td>
<td>0.26</td>
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<tr>
<td>8 – 21 d</td>
<td>0.97</td>
<td>0.97</td>
<td>0.95</td>
<td>0.95</td>
<td>0.99</td>
<td>0.99</td>
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<tr>
<td>22 – 35 d</td>
<td>1.81</td>
<td>2.00</td>
<td>1.87</td>
<td>1.98</td>
<td>1.98</td>
<td>1.89</td>
</tr>
<tr>
<td><strong>BW, 35 d</strong></td>
<td>43.8</td>
<td>44.5</td>
<td>43.3</td>
<td>44.8</td>
<td>44.6</td>
<td>44.8</td>
</tr>
</tbody>
</table>
Gain:feed Phase II

1. Control
2. FM
3. MEPRO
4. Control +A
5. FM +A
6. MEPRO +A

Values:
- Control: 5%
- FM: 4%
- MEPRO: 6%
- Control +A: 4%
- FM +A: 6%
- MEPRO +A: 6%
Diarrhea score

Group 1

pens treated
Control – 63 %
FM – 63 %
MEPRO – 50 %

Group 2
## Intestinal health and digestive capacity

<table>
<thead>
<tr>
<th>Item</th>
<th>Control</th>
<th>FM</th>
<th>MEPRO</th>
<th>Control +A</th>
<th>FM +A</th>
<th>MEPRO +A</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stomach</td>
<td>4.23</td>
<td>3.56</td>
<td>3.62</td>
<td>3.80</td>
<td>4.01</td>
<td>3.88</td>
<td>0.28</td>
</tr>
<tr>
<td>Duodenum</td>
<td>5.12</td>
<td>5.54</td>
<td>5.30</td>
<td>5.38</td>
<td>4.66</td>
<td>5.53</td>
<td>0.31</td>
</tr>
<tr>
<td>Jejunum</td>
<td>6.40</td>
<td>6.38</td>
<td>5.93</td>
<td>6.43</td>
<td>6.68</td>
<td>6.19</td>
<td>0.30</td>
</tr>
<tr>
<td>Ileum</td>
<td>6.99</td>
<td>6.88</td>
<td>7.00</td>
<td>6.72</td>
<td>7.05</td>
<td>7.02</td>
<td>0.30</td>
</tr>
</tbody>
</table>

**Intestinal alkaline phosphatase activity**

(µmol/mg per minute)
Conclusions

• MEPRO is suitable as a replacement for FM
  – Similar digestibility
  – Lesser impact of age on digestibility
  – Impact on gain:feed
  – Reduced diarrhea severity and incidence
    • Intestinal pH/digestive capacity/inflammation
Study 2 - objectives

• Assess MEPRO as an alternative for fishmeal and plasma proteins on nursery pig performance and immune function
Study 2 – animals and diets

- 240 weaned pigs (21 d of age; 14.3 ± 0.7 lbs); 10 pens/trt; 5 wks

<table>
<thead>
<tr>
<th>Item</th>
<th>Control</th>
<th>MEPRO (-FM)</th>
<th>MEPRO (-SDP)</th>
<th>MEPRO (-FM-SDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>42.7 (56.4)</td>
<td>41.1 (54.9)</td>
<td>37.6 (51.3)</td>
<td>34.4 (48.0)</td>
</tr>
<tr>
<td>SBM, standard</td>
<td>15.0 (22.0)</td>
<td>15.0 (22.0)</td>
<td>15.0 (22.0)</td>
<td>15.0 (22.0)</td>
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<tr>
<td>Whey</td>
<td>25.0 (10.0)</td>
<td>25.0 (10.0)</td>
<td>25.0 (10.0)</td>
<td>25.0 (10.0)</td>
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<tr>
<td>Fishmeal</td>
<td>7.5 (5.0)</td>
<td>-</td>
<td>7.5 (5.0)</td>
<td>-</td>
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<tr>
<td>Blood plasma</td>
<td>6.5 (3.0)</td>
<td>6.5 (3.0)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>MEPRO</td>
<td>-</td>
<td>7.5 (5.0)</td>
<td>12.0 (8.0)</td>
<td>20.0 (15.0)</td>
</tr>
</tbody>
</table>

Zn 4000 ppm, Phase I; 2000 ppm Phase II
Study 2 - observations

• BW and feed disappearance weekly
• Innate immune response
  – Lymphocyte proliferation
• Adaptive immune response
  – Antibody- and cell-mediated immune response
# Growth performance

<table>
<thead>
<tr>
<th>Item</th>
<th>Control</th>
<th>MEPRO (-FM)</th>
<th>MEPRO (-SDP)</th>
<th>MEPRO</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW, lbs</td>
<td></td>
<td></td>
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<tr>
<td>Phase I</td>
<td>15.7</td>
<td>14.9</td>
<td>14.3</td>
<td>14.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Phase II</td>
<td>27.7(^a)</td>
<td>26.7(^a,b)</td>
<td>25.1(^b)</td>
<td>26.0(^a,b)</td>
<td>0.7</td>
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<tr>
<td>Phase III</td>
<td>46.6</td>
<td>45.4</td>
<td>44.5</td>
<td>45.8</td>
<td>1.1</td>
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<tr>
<td>ADG, lbs/d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Phase I</td>
<td>0.134</td>
<td>0.078</td>
<td>-0.013</td>
<td>0.014</td>
<td>0.027</td>
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<tr>
<td>Phase II</td>
<td>0.897(^x)</td>
<td>0.888(^x,y)</td>
<td>0.802(^y)</td>
<td>0.858(^x,y)</td>
<td>0.028</td>
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<tr>
<td>Phase III</td>
<td>1.329</td>
<td>1.293</td>
<td>1.372</td>
<td>1.404</td>
<td>0.036</td>
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</table>
# Growth performance

<table>
<thead>
<tr>
<th>Item</th>
<th>Control</th>
<th>MEPRO (-FM)</th>
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<th>MEPRO</th>
<th>SEM</th>
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<tbody>
<tr>
<td>ADF, lbs/d</td>
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<tr>
<td>Phase I</td>
<td>0.267</td>
<td>0.233</td>
<td>0.221</td>
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<td>2.022</td>
<td>2.090</td>
<td>2.097</td>
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<td>Gain:feed</td>
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<tr>
<td>Phase I</td>
<td>0.274</td>
<td>0.016</td>
<td>-0.841</td>
<td>-0.190</td>
<td>0.272</td>
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<tr>
<td>Phase II</td>
<td>0.802&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>0.827&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.795&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>0.767&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.015</td>
</tr>
<tr>
<td>Phase III</td>
<td>0.658</td>
<td>0.639</td>
<td>0.669</td>
<td>0.676</td>
<td>0.025</td>
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The impact of subclinical health and week 1 performance
Enhanced adaptive immunity
Conclusions

• MEPRO suitable to replace fishmeal and spray dried plasma based on performance
  – Alter immune system to enhance adaptive immune response
  – Ingredient interaction (FM and MEPRO)
Other published evidence

• Growth performance – nursery pigs
  – Improved daily gain and feed intake (Min et al., 2004)
  – Improved gain and feed efficiency when included with porcine solubles but not alone or in combination with FM (Jones et al., 2010)
  – Reduced diarrhea score (Song et al., 2010)

• Understanding biological mechanisms beyond pig growth to allow development of products with greater consistency in multiple environmental settings
Acknowledgements

• Prairie Aquatech, Brookings, SD
• Kemin, Des Moines, IA
• National Pork Board (#14-138)