Non-nutrients in Swine Health and Production

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Outline

• World population & calorie demand
• Non-nutrients - a novel concept
• Examples
• Overall summary
• Take home message
World population

Food calories

1965 = 100

Calories

Population

Global demand for meat

2005 vs. 2050
(in tonnes)

Source: Food and Agriculture Organization of the United Nations, ESA Working Paper No. 12-03, p. 131
Swine production

- Technologies
  - Genetics
  - Management
  - Reproduction
  - Health
  - Nutrition
Non-nutrients

- Bioactive compounds
- No nutrient contribution to animals
- But, have physiological activities beyond provision of bioactive compounds
Antibiotics
Livestock antibiotics use

2010: 63,000 tons

Van Boeckel et al., 2015
Antibiotics in feed

• Treat Disease

• Growth promoter
  ✓ Antibiotic resistance
  ✓ Banned in the European Union since 2006
  ✓ Increasing restricted in the U.S.
    • FDA’s GFI #213
Non-nutritive sweeteners
Artificial sweeteners

• Synthetic sugar substitutes
• Intensive sweeteners
• Pleasant taste, enhance palatability, reinforce taste preference, and promote consumption
Feeding artificial sweeteners increased feed intake of weaning pigs

Sterk et al., 2008

P-value feed*day = 0.717

150 mg/kg
Sweeteners enhanced glucose uptake of weaning pigs

NHDC = neohesperidin dihydrochalcone

Moran et al., 2010
Sweeteners enhanced expression of glucose co-transporters in weaning pigs

NHDC = neohesperidin dihydrochalcone

Moran et al., 2010
Artificial sweeteners

- Pre- & post-weaning periods
- Improve feed intake
- Improve feed efficiency
- Prevent weaning-related malabsorption
Exogenous enzymes
Anti-nutritional factors

• Anti-nutritional factors in animal feed
  ✓ Examples: phytic acid, glucosinolates, non-starch polysaccharides
  ✓ Reducing amino acid digestibility
  ✓ Binding to various nutrients
  ✓ Disturbing intestinal functions
Exogenous enzymes

- Exogenous enzymes help to degrade the indigestible components in diet and help to alleviate the negative effects of anti-nutritional factors
<table>
<thead>
<tr>
<th>Enzyme</th>
<th>Main substrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phytase</td>
<td>Phytic acid</td>
</tr>
<tr>
<td>Xylanase</td>
<td>Arabinoxylans</td>
</tr>
<tr>
<td>Galactosidase</td>
<td>Galatosides</td>
</tr>
<tr>
<td>Mannanase</td>
<td>β-mannans</td>
</tr>
<tr>
<td>Protease</td>
<td>Proteins</td>
</tr>
</tbody>
</table>
The graph shows the effects of dietary phytase on bone weight, bone ash, and bone P in weaning pigs. The y-axis represents grams (g), and the x-axis represents bone weight, bone ash, and bone P. The bars are labeled with letters (a, b) and indicate statistical significance: Linear: *P < 0.05*. The colors of the bars represent different dietary conditions: blue for Negative control, orange for 250 FTU/kg phytase, and gray for 500 FTU/kg phytase. The graph is from Liu et al., 2016.
Dietary phytase improved growth performance of pigs fed P-deficient diets

Liu et al., 2016
# Xylanase improved energy digestibility of pigs

<table>
<thead>
<tr>
<th>Item</th>
<th>Full-fat rice bran</th>
<th>Defatted rice bran</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDF, %</td>
<td>10.36</td>
<td>13.29</td>
</tr>
<tr>
<td>ADF, %</td>
<td>5.65</td>
<td>6.61</td>
</tr>
<tr>
<td>Hemicellulose, %</td>
<td>4.71</td>
<td>6.68</td>
</tr>
<tr>
<td>ME without xylanase, kcal/kg</td>
<td>3,856</td>
<td>2,936</td>
</tr>
<tr>
<td>ME with xylanase, kcal/kg</td>
<td>4,198</td>
<td>3,225</td>
</tr>
</tbody>
</table>

ME: metabolizable energy    Xylanase dose: 16,000 units/kg

*Casas and Stein, 2016*
Exogenous enzymes

• Improve digestibility of nutrients and energy

• Improve sustainability of pig production by increasing the utilization of fibrous by-products in pigs
Probiotics & prebiotics
Probiotics & prebiotics

- **Probiotics**: live microorganisms that have beneficial effects on the host when ingested

- **Prebiotics**: compounds able to improve the growth of beneficial microbes in the GI tract

Salminen et al., 1998
Gilson et al., 2004
Probiotics

• Main categories
  • *Bacillus* (Gram +, spore-formers)
  • Lactic acid-producing bacteria
    • *Lactobacillus*, *Bifidobacterium*, *Enterococcus*
  • Yeast
Prebiotics

• Inulin
• Fructo-oligosaccharides
• Galacto-oligosaccharides
• Transgalacto-oligosaccharides
• Soy oligosaccharides
• Lactose
• etc.
Probiotics: LGG

LGG = *Lactobacillus rhamnosus*  
Dose: $10^9$ CFU/g  
Weanling pigs: 6.7 kg BW

Mao et al., 2016
### Probiotics: LGG

**Ileal mucosa**

- **Lactobacillus**
  - Control: 4.2 Log10 (copies/g)
  - LGG: 5.1 Log10 (copies/g)
- **Bifidobacterium**
  - Control: 2.0 Log10 (copies/g)
  - LGG: 3.0 Log10 (copies/g)
- **E. coli**
  - Control: 6.7 Log10 (copies/g)
  - LGG: 7.8 Log10 (copies/g)

**LGG** = *Lactobacillus rhamnosus*  
**Dose:** $10^9$ CFU/g

**Weanling pigs:** 6.7 kg BW  

*Mao et al., 2016*
Prebiotics: fructan

Growing pigs: 73 kg BW

Zhao et al., 2013
Prebiotics: fructan

Growing pigs: 73 kg BW

Zhao et al., 2013
Probiotics & prebiotics

Potential mechanisms

Probiotic microbes

- Completing binding sites and nutrients
- Metabolites
- Modulation of immune system

- Inhibit pathogens
- Inhibit pathogen attachment
- Increase gut barrier function
- Modulate immunity
- Alter nutrient digestibility
Plant extracts
Plant extracts

• Concentrated, hydrophobic, volatile aroma
• Mixtures of secondary plant metabolites
• Biological effects:
  ✓ Antimicrobial
  ✓ Anti-inflammatory
  ✓ Antioxidant
  ✓ Others: Antiviral, Antifungal, Antiparasitic, Antitoxigenic
Frequency of diarrhea

Pig days with diarrhea score ≥ 3
1, normal; 5, watery diarrhea

Liu et al., 2013
Possible mechanism for reduced diarrhea

- Ileal villi height (d 5 PI)
- MUC2 in ileal mucosa (d 5 PI)

- Possibly improved gut barrier function!

Liu et al., 2013, 2014
Plant extracts reduced systemic inflammation caused by *E. coli* infection

**White blood cell counts**

**Serum TNF-α**

*Liu et al., 2013*
Plant extracts reduced gut inflammation caused by *E. coli* infection

**Ileal mucosa, d 5 PI**

- **Macrophage**
  - Control
  - Capsicum
  - Garlicon
  - Turmeric

- **Neutrophil**
  - Control
  - Capsicum
  - Garlicon
  - Turmeric

**Relative mRNA expression**

- **COX-2**
  - Control
  - Capsicum
  - Garlicon
  - Turmeric

- **TNFA**
  - Control
  - Capsicum
  - Garlicon
  - Turmeric

*Liu et al., 2013*
Plant extracts

- Weanling pigs
- Increase disease resistance
- Enhance gut barrier function
- Modify immune responses
Overall summary

• Non-nutrients
  ✓ Nutrient digestibility or absorption
  ✓ Gut microbial ecology
  ✓ Gut integrity and barrier function
  ✓ Host immune responses
Take home message

• The importance of using non-nutrients will be increased to maintain pig health and promote grow performance

• More research are needed for the best practical solutions for swine health and production
Acknowledgement

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• Symposium committee
• Pancosma
• ASAS
Non-nutrition: the future of nutrition?

Liu Animal Nutrition Laboratory

• Nutrients & Non-nutrients on gut health of weaning pigs

http://liu.faculty.ucdavis.edu/