Dietary phytonutrients enhance disease resistance of pigs

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Outline

• Previous knowledge
• Hypothesis
• Test of hypothesis
• What does it mean?
Weaning stress

- Maternal separation
- Environmental change
- Increased exposure to pathogens
- Social hierarchy stress
- Move to solid feed
- Transportation stress
Gut morphology change of weanling pigs

- Reduced feed intake
- Negative effects on intestinal morphology
Declined intestinal functions

- Reduced brush-border enzyme activity
- Reduced absorption ability
- Diarrhea
- Poor growth performance
Immunity of weanling pigs

- Passive immunity is declining
- Active immunity is not fully developed

* Highly sensitive to infectious disease
* Divert nutrients away from growth to immune response
* Poor growth performance
Antibiotic use on farms

Van Boeckel et al., 2015 PNAS
Feed additives

• Mannan oligosaccharides
• Immune egg products
• Direct-fed bacteria
• Yeast/yeast products
• Plant extracts
Plant extracts

- Extracted from parts of plants or synthesized
- Concentrated, hydrophobic, volatile aroma
- Mixtures of secondary plant metabolites
- Liquid or powder
- Phenolic compounds
Plant extracts

• Biological effects:

✓ Antimicrobial
✓ Anti-inflammatory
✓ Antioxidant
✓ Others: Antiviral, Antifungal, Antiparasitic, Antitoxogenic
Hypothesis

1) Certain plant extracts modify immune function of pigs

2) This leads to increased disease resistance
Test of hypothesis

- Exp. 1: In vitro cell culture
- Exp. 2: *E. coli* challenge study
- Exp. 3: PRRS challenge study
Experiment 1

In vitro cell culture assays
Anti-inflammatory effects

LPS-stimulated porcine alveolar macrophages

*P < 0.05

Liu et al., 2012
Anti-inflammatory effects

LPS-stimulated porcine alveolar macrophages

*P < 0.05

Liu et al., 2012
Conclusions – Exp. 1

• All of plant extracts used in this experiment may have potent anti-inflammatory effects

• Carvacrol, cinnamaldehyde, eugenol, and garlicon might be the more powerful candidates

• Capsicum oleoresin, garlicon, and turmeric oleoresin were selected to do *E. coli* and PRRSV challenge studies
In vivo *E. coli* challenge study

*Liu et al., 2013a*
Procedures

Weaning (21 d old) d-4

F18 *E. coli* inoculation (d0 to d2)

Sows screening

White blood cell counts
Cytokines
Acute phase proteins

Immunohistochemistry
Intestinal morphology
qPCR & Microarray (d 5)

* 4 diets: control, 10 ppm capsicum oleoresin, 10 ppm garlic, 10 ppm turmeric oleoresin

Liu et al., 2013a
Frequency of diarrhea

Sham

Control vs. plant extracts
$P < 0.05$

E. coli

Control vs. plant extracts
$P < 0.05$

Pig days with diarrhea score $\geq 3$
1, normal; 5, watery diarrhea

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

**White blood cell counts**

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Capsicum</th>
<th>Garlicon</th>
<th>Turmeric</th>
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<tr>
<td>d5 PI</td>
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<td>d11 PI</td>
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**Serum TNF-α**

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

Ileal mucosa, d 5 PI

- Control
- Capsicum
- Garlicon
- Turmeric

Number/mm²

**Ileum (d 5 PI)**

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

Liu et al., 2014

**The Prostaglandin Pathway**

- Arachidonic acid
- TNF-α

**Cyclooxygenase-2 (COX-2)**

- PGG2
- PGH2
- PGG2
- PGH2
- PGG2
- PGH2

**Inflammation!**

Liu et al., 2014
Conclusions – Exp. 2

- Feeding plant extracts reduced diarrhea and enhanced disease resistance of weanling pigs

- Possible mechanisms
  - Gut barrier function
  - Gut mucosa immunity
  - Systemic immunity
In vivo porcine reproductive and respiratory syndrome virus (PRRSV) challenge study

Liu et al., 2013b
Rectal temperature

- d 7, 9, 11: PRRSV: $P < 0.01$

* CAP vs. CON: $P < 0.05$
# GAR vs. CON: $P < 0.05$

Liu et al., 2013b
Feed efficiency, d 0-14

PRRSV: $P = 0.07$

Liu et al., 2013b
Serum viral load-PRRSV

CON vs. PE: $P < 0.05$

CON vs. PE: $P = 0.05$

d 7 & 14: PRRSV: $P < 0.01$

Liu et al., 2013b
Serum TNF-α - PRRSV

CON vs. PE: \( P < 0.05 \)

\[ \text{d 7 & 14: PRRSV: } P < 0.01 \]
Serum C-reactive protein - PRRSV

CON vs. PE: $P < 0.05$

d 7 & 14: PRRSV: $P < 0.01$

Liu et al., 2013b
Conclusions – Exp. 3

• Feeding plant extracts delayed fever caused by PRRS infection
• Feeding plant extracts improved feed efficiency of pigs
• Possible mechanisms
  • Reduced viral load
  • Reduced systemic inflammation
Hypothesis

1) Certain plant extracts modify immune function of pigs  Accept

2) This leads to increased disease resistance  Accept
Acknowledgements

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• Pancosma
Comparative Animal Nutrition & Physiology Laboratory

http://animalnutr-ansci.faculty.ucdavis.edu/