Dietary phytonutrients enhance disease resistance of pigs

Yanhong Liu,*¹ D. Bravo,² and J. E. Pettigrew³

University of California, Davis, USA¹, Pancosma SA, Geneva, Switzerland², and University of Illinois, Urbana, USA³
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, Antitoxigenic
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

**Anti-inflammatory effects**

IL-1β

LPS-stimulated porcine alveolar macrophages

*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
Experiment 2

In vivo *E. coli* challenge study

*Liu et al., 2013a*
Procedures

Sows screening

Weaning (21 d old) d-4

F18 E. coli inoculation (d0 to d2)

Daily diarrhea

Fecal culture

White blood cell counts
Cytokines
Acute phase proteins

Immunohistochemistry
Intestinal morphology
qPCR & Microarray (d 5)

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

Liu et al., 2013a
Frequency of diarrhea

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

Control vs. plant extracts
P < 0.05

Liu et al., 2013a
Possible mechanism for reduced diarrhea

- Possibly improved gut barrier function!

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

Liu et al., 2013a

**White blood cell counts**

**Serum TNF-α**
Plant extracts reduced gut inflammation caused by *E. coli* infection

Sham Macrophage

E. coli Macrophage

Ileum (d 5 PI)

Ileal mucosa, d 5 PI

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<tr>
<th></th>
<th>Control</th>
<th>Capsicum</th>
<th>Garlicon</th>
<th>Turmeric</th>
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*Liu et al., 2013a*
Plant extracts reduced gut inflammation caused by *E. coli* infection

Liu et al., 2014

The Prostaglandin Pathway

![Graph showing relative mRNA expression of COX-2 and TNFA for different treatments: Control, Capsicum, Garlicon, and Turmeric.](chart.png)

The Prostaglandin Pathway

- Arachidonic acid
- TNF-α
- Cyclooxygenase-2 (COX-2)
- PGG2
- PGH2
- TXA2
- PGF2α
- PGE2
- PGD2
- PGI2

↑ 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
Experiment 3

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

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: $P < 0.01$

Control
Capsicum
Garlic
Turmeric

Liu et al., 2013b
Serum TNF-α - PRRSV

CON vs. PE: $P < 0.05$

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

Liu et al., 2013b
Serum C-reactive protein - PRRSV

CON vs. PE: $P < 0.05$

$\text{d 7 \& 14: PRRSV: } P < 0.01$

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