New research into plant-based feed additives

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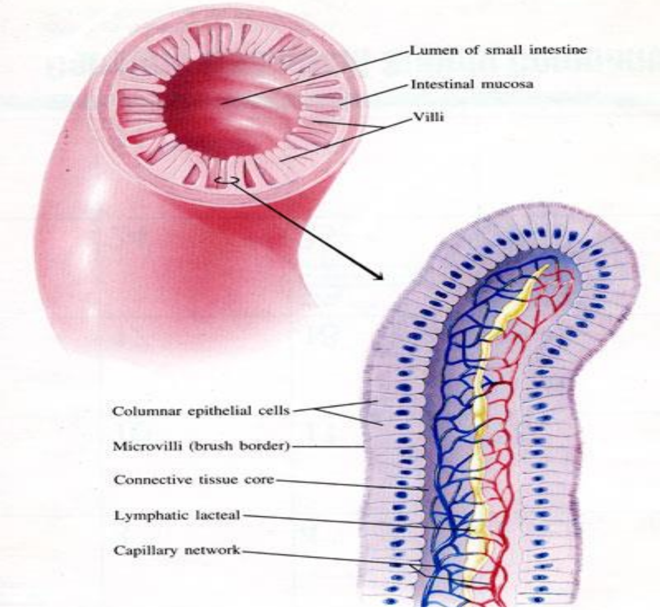
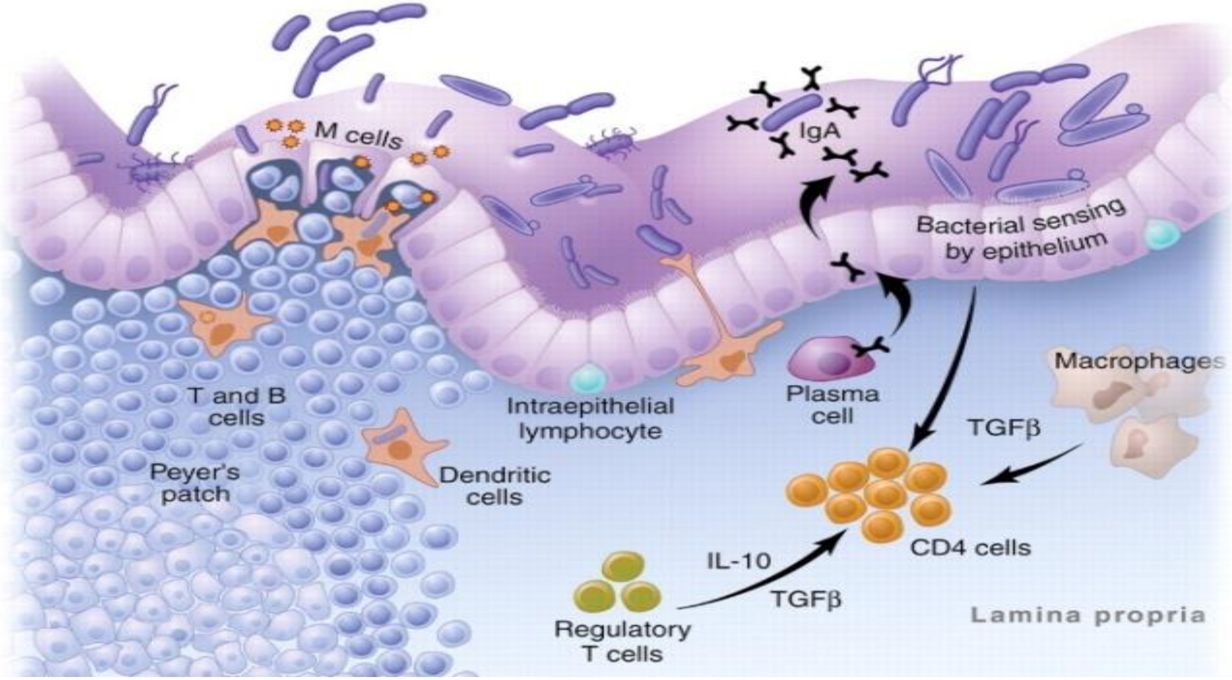
Outline

- Weaning stress on intestinal development and health of pigs
- How to define a healthy gut
- Plant-based feed additives
  - Phytochemicals
  - Algae-derived products
- Take home message

Focus on the GUT

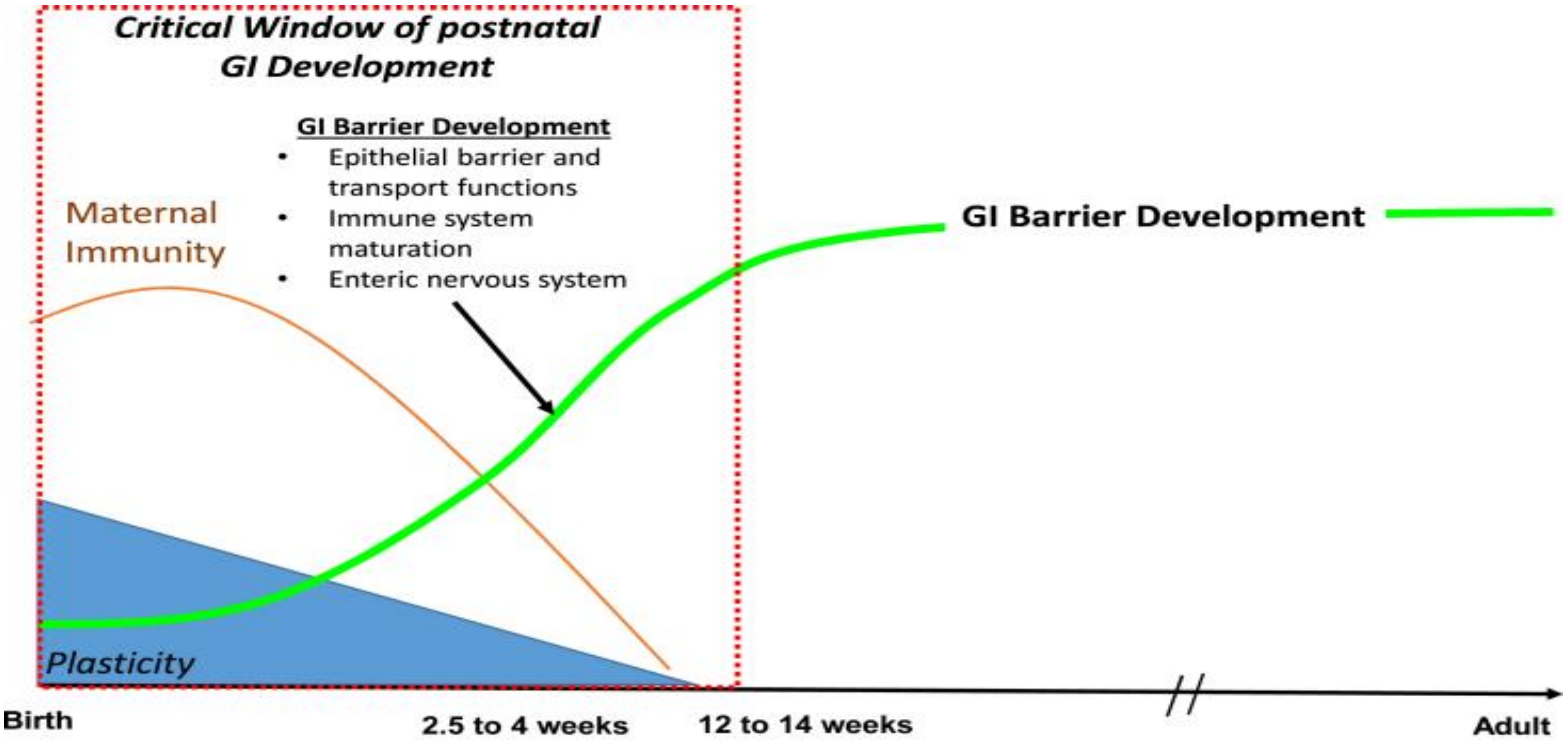
- **Digestion and absorption of nutrients**
- **Physical barrier against pathogenic agents**
- **Large immune organ**
- **Nutrient chemo-sensing**





MacDonald and Monteleone, 2005

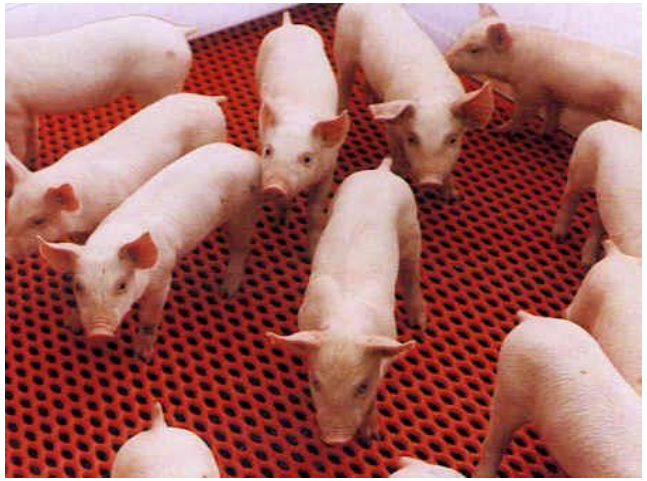
Focus on the GUT of weaning pigs



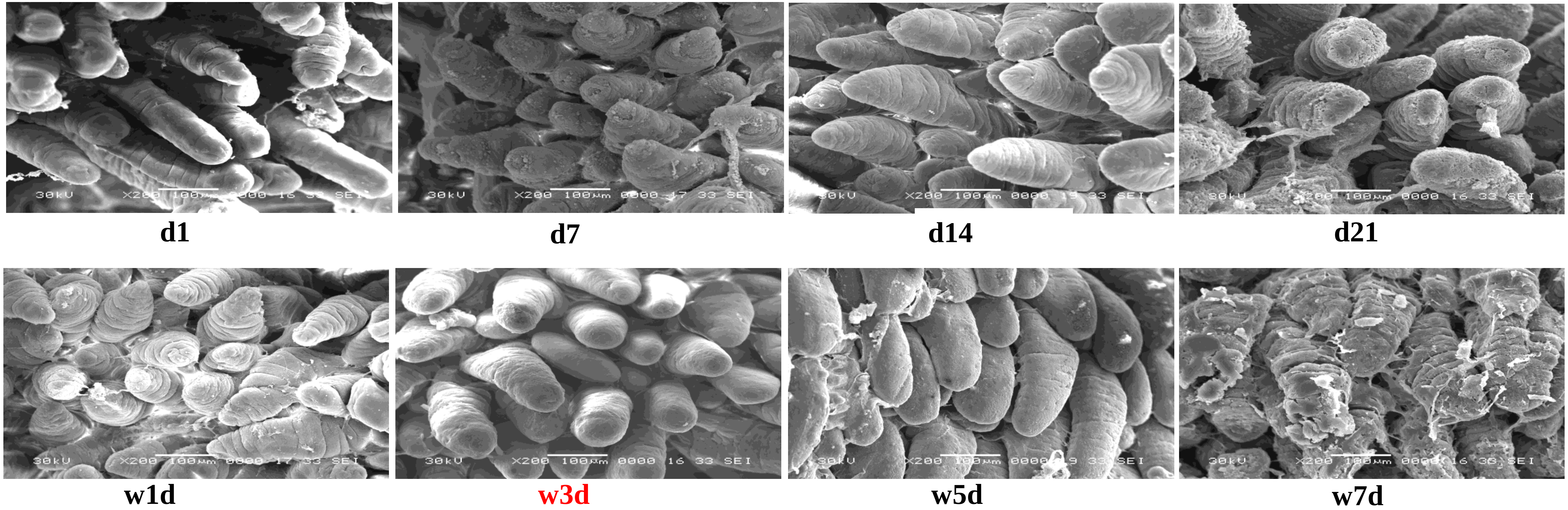
Moeser et al., 2017

Weaning stress

- Maternal separation
- Environmental change
- Increased exposure to pathogens
- Social hierarchy stress
- Move to solid feed
- Transportation stress



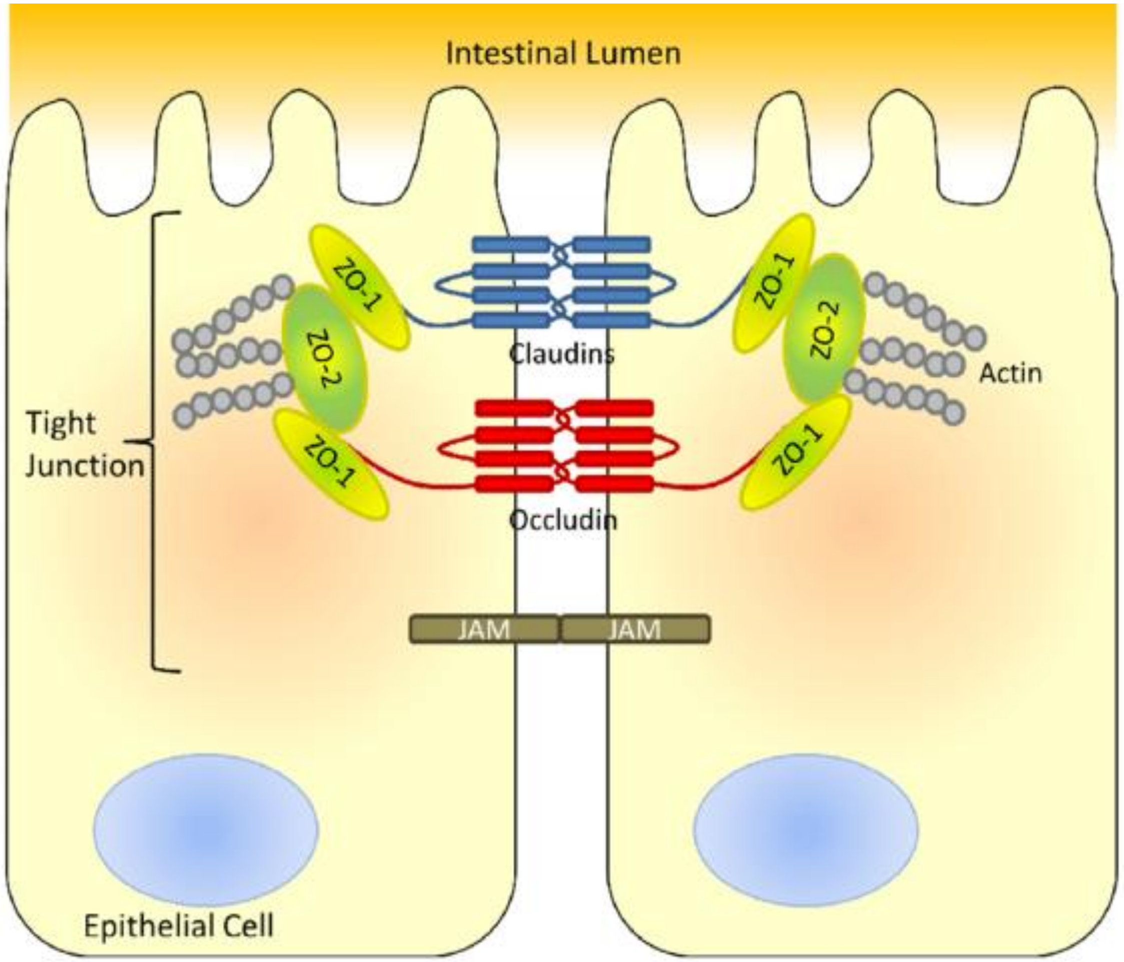
Weaning stress on intestinal morphology

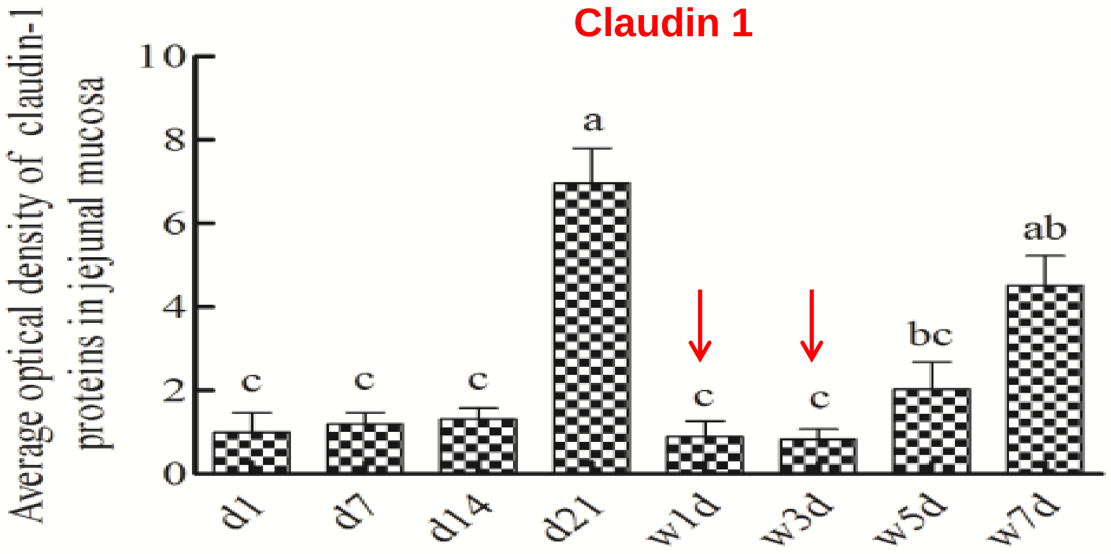


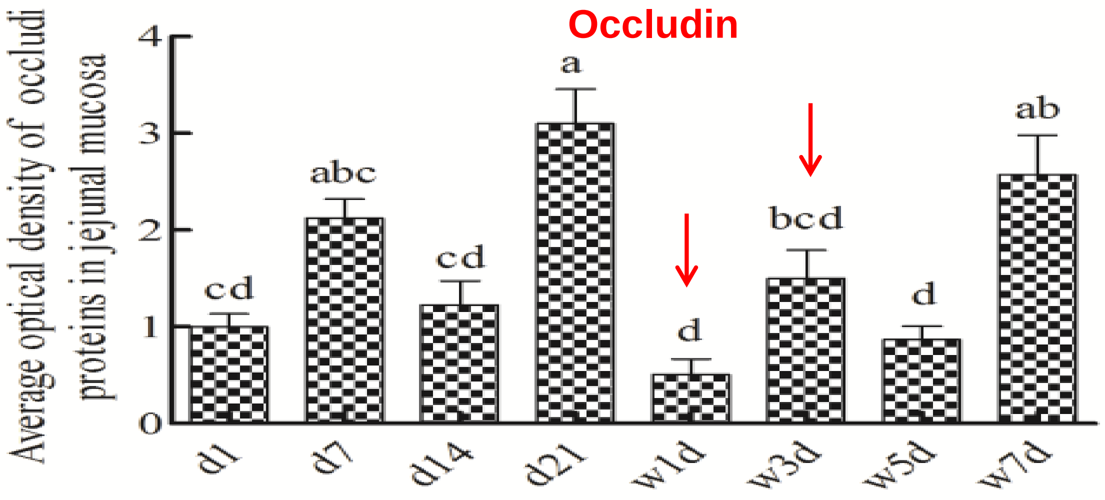
- **Pre-weaning: d 1 to 21, villi surface was increased**
- **Post-weaning: reduced villi number and folding**

Wang et al., 2016

Weaning stress on intestinal barrier function



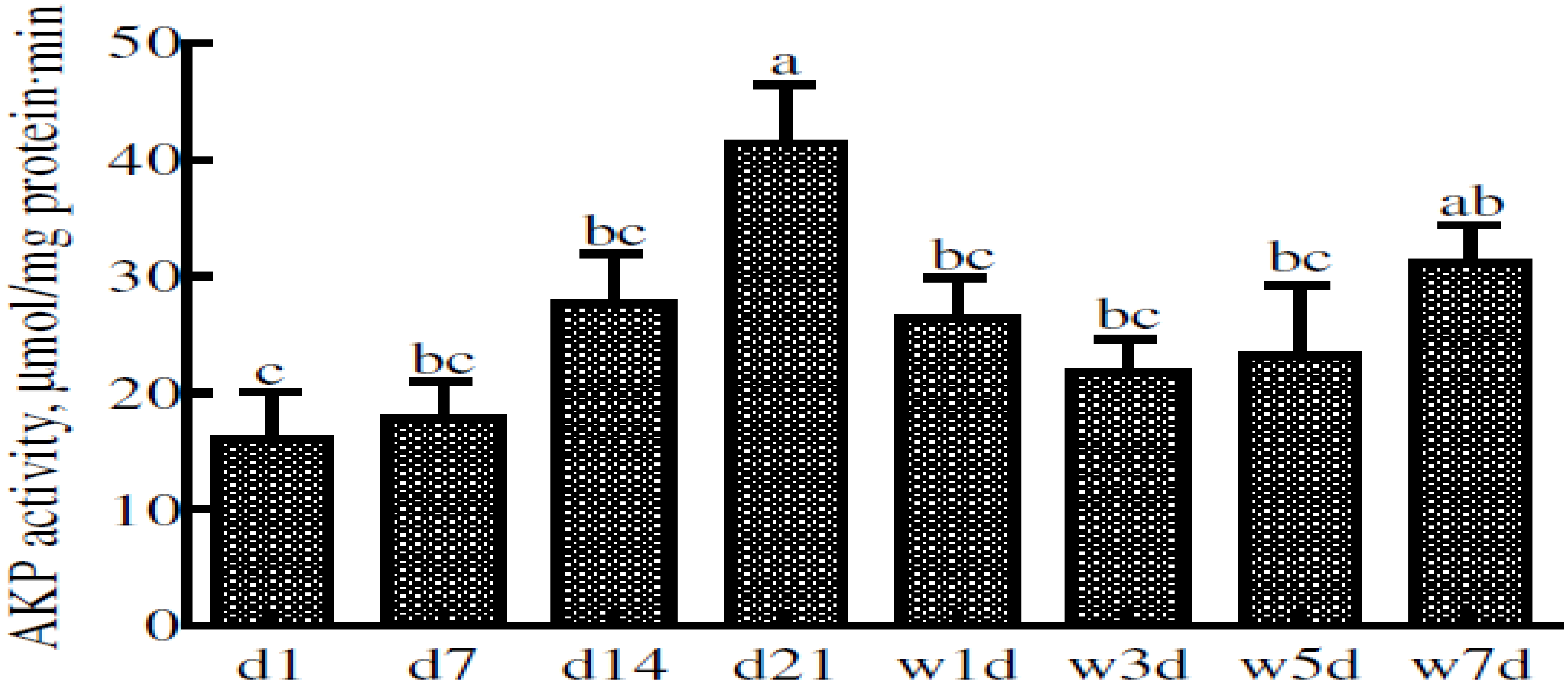




Neunlist et al., 2013; Wang et al., 2016

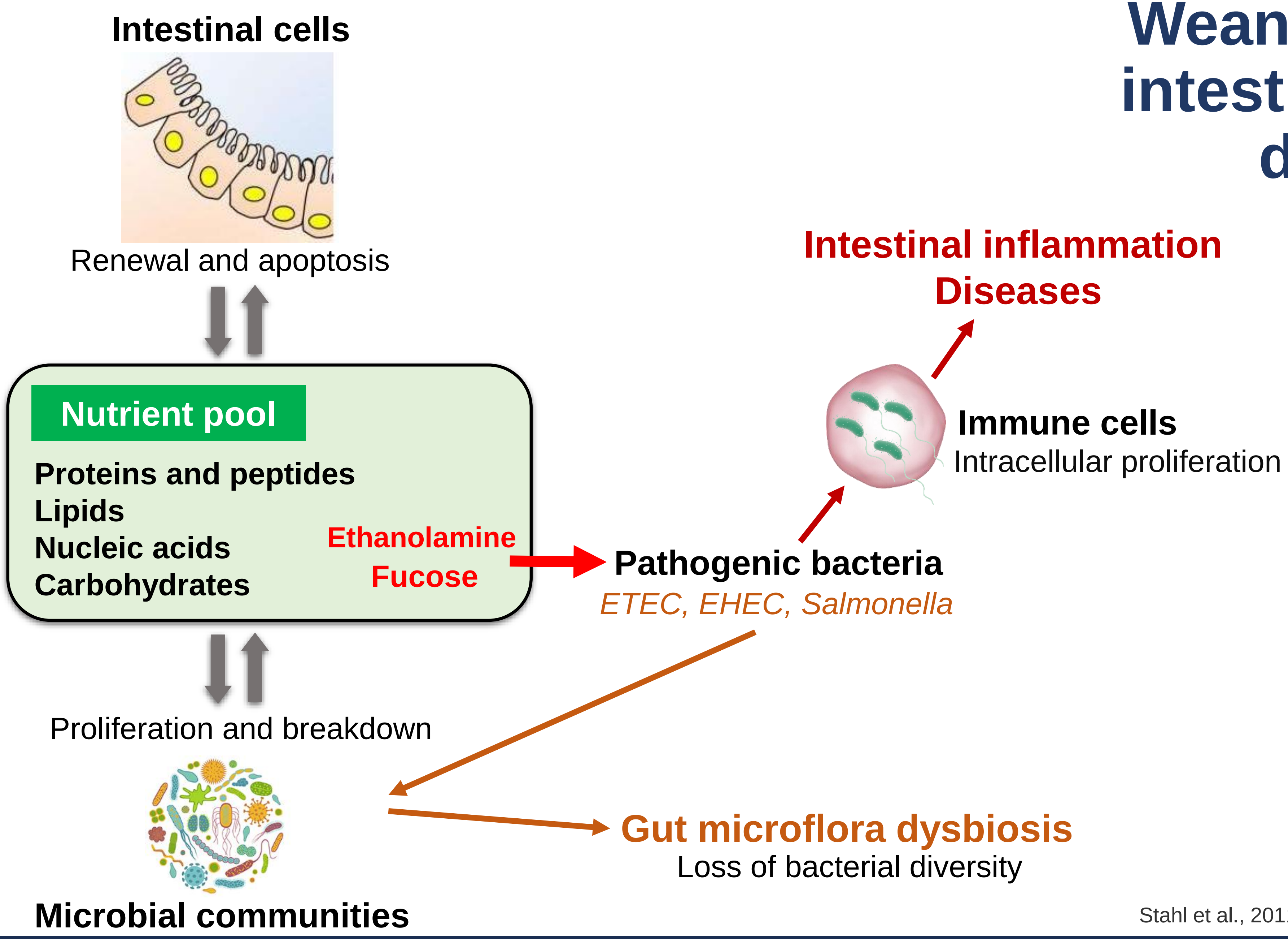
UCDAVIS

Weaning stress on intestinal barrier function, cont.



Wang et al., 2016

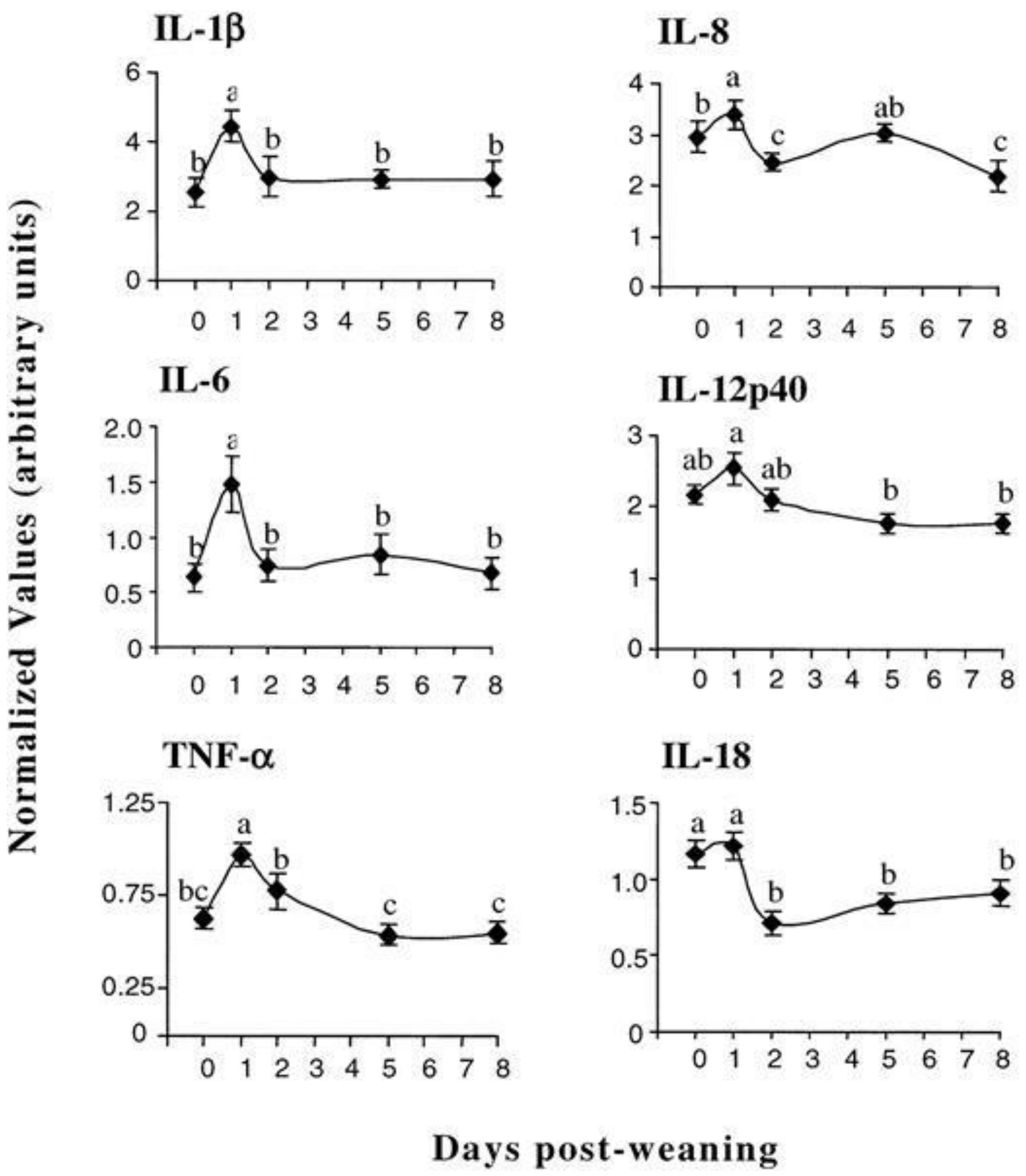
Weaning stress on intestinal microbial dysbiosis



Stahl et al., 2011; Thiennimitr et al., 2011; Xiong et al., 2019

Weaning stress on intestinal mucosal immunity

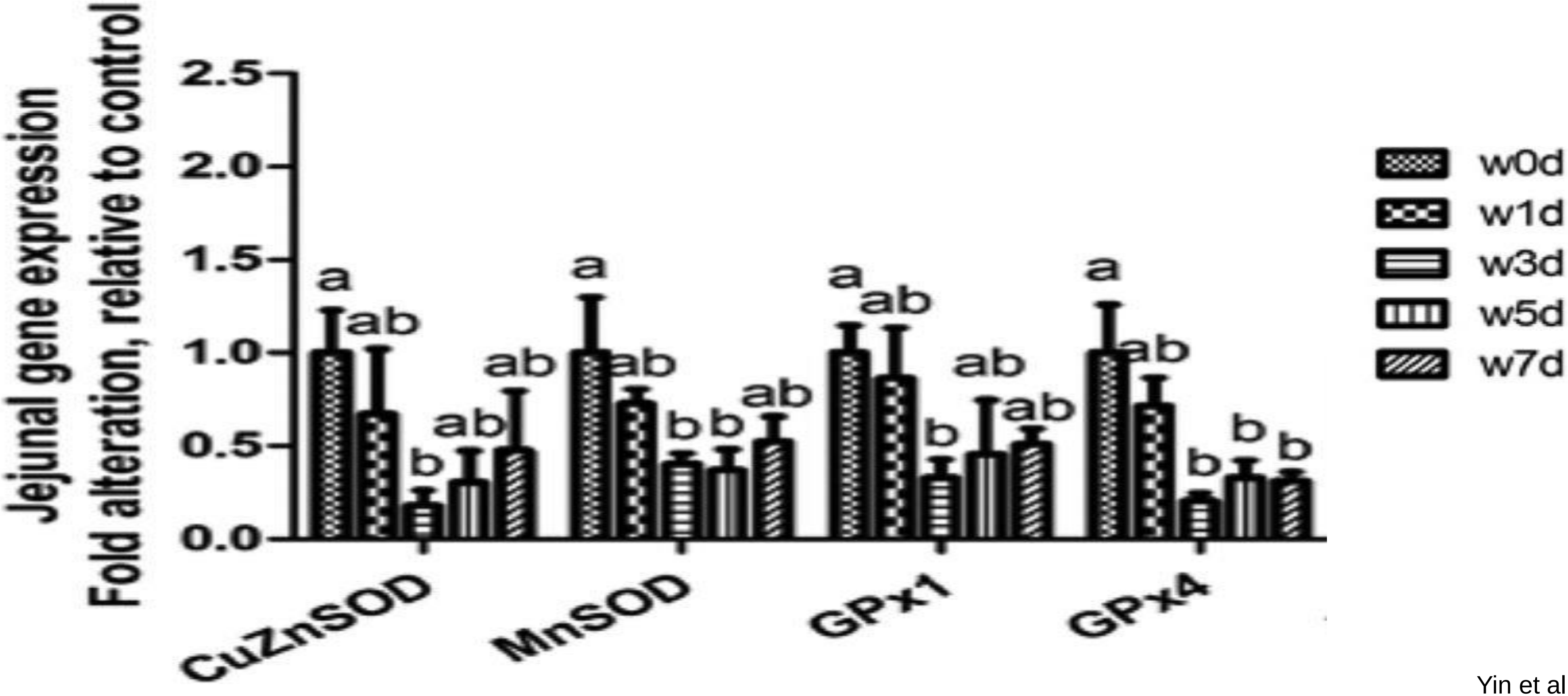
Middle of the small intestine



- **Weaning induces a transient gut inflammation in pigs**
  - **Enhanced pro-inflammatory cytokines**
  - **Increased intestinal CD4+ and CD8+ T lymphocytes**
  - **Up-regulated matrix metalloproteinase**
  - **Down-regulated MHC I expression**
  - **Reduced secretory IgA**

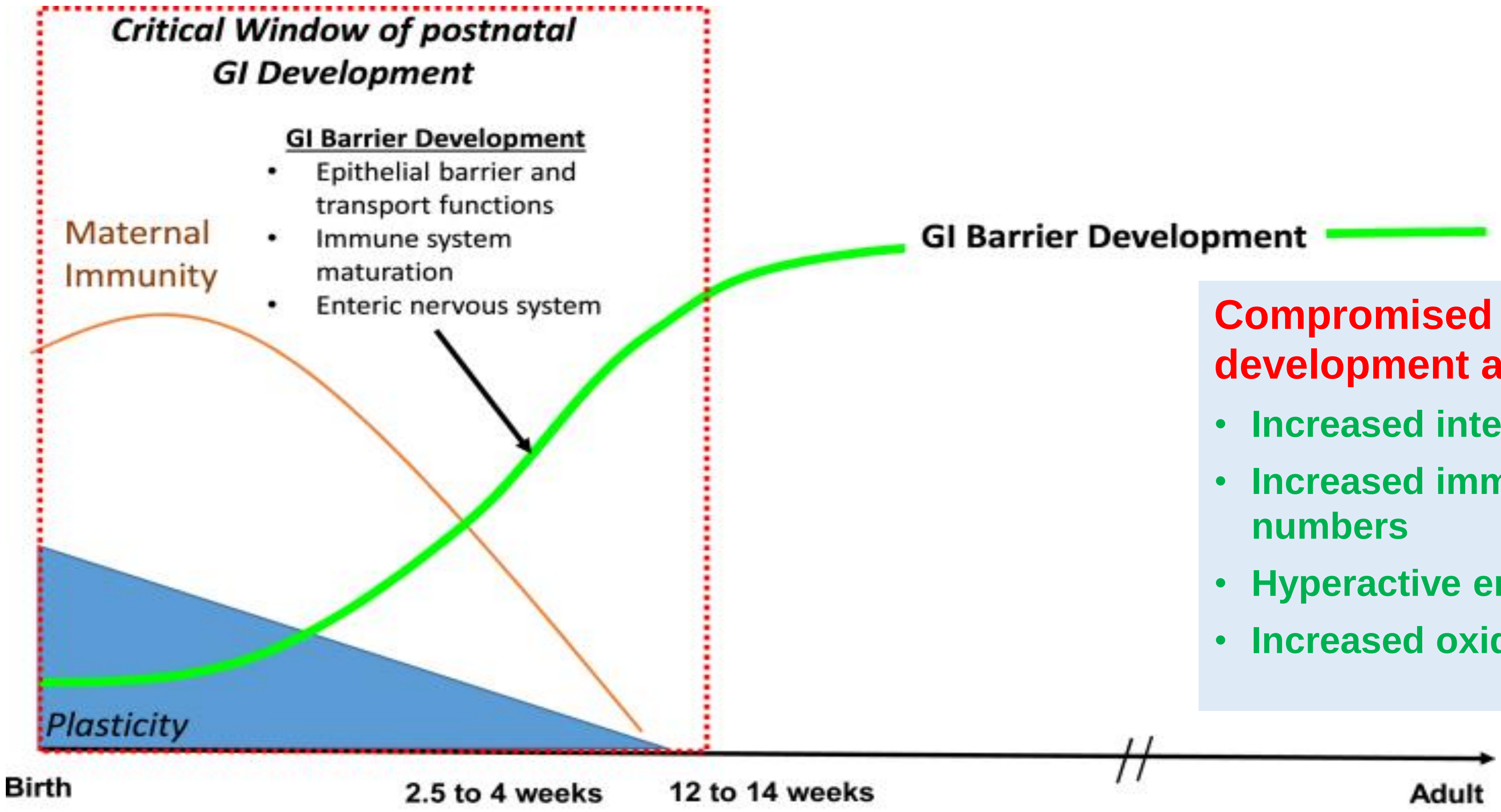
McCracken et al., 1999; Pié et al., 2004

Weaning stress on intestinal oxidative status



Yin et al., 2014

Focus on the GUT of weaning pigs



Compromised intestinal barrier development and function

- **Increased intestinal permeability**
- **Increased immune cell activity and numbers**
- **Hyperactive enteric nervous system**
- **Increased oxidation**

Moeser et al., 2017

How to define a healthy gut

- **Effective nutrient digestion and absorption**
- **Effective waste excretion**
- **A**
- **A ... absence of diseases)**
- **A functional and protective gut immunity**
- **A minimal activation of stress/neural pathways**

Overall, should be concomitant with optimal performance

Pluske et al., 2018

Nutritional strategies

- Optimization of feed formulation
- Utilization of low protein diet in post-weaning period
- Enhancement of feed processing and manufacturing
- Supplementation of feed additives

Feed additives

- Improvement of nutrient digestion and absorption (i.e. exogenous enzymes)
- Regulation of gut microbiota to more favorable bacterial species (i.e. prebiotics & probiotics)
- Immune modulation to enhance disease resistance of weaned pigs (i.e. β-glucan, phytochemicals)

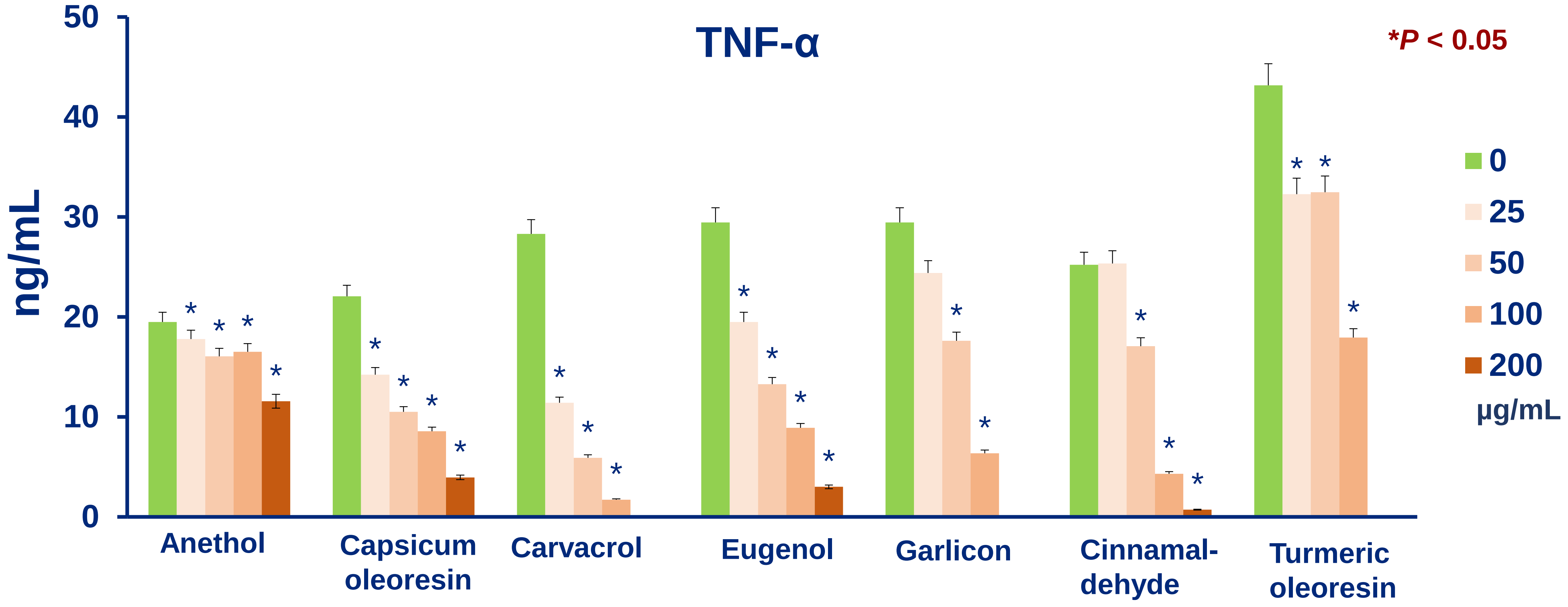
Plant-based feed additives

- Phytochemicals
- β-glucan

Phytochemicals - plant extracts

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

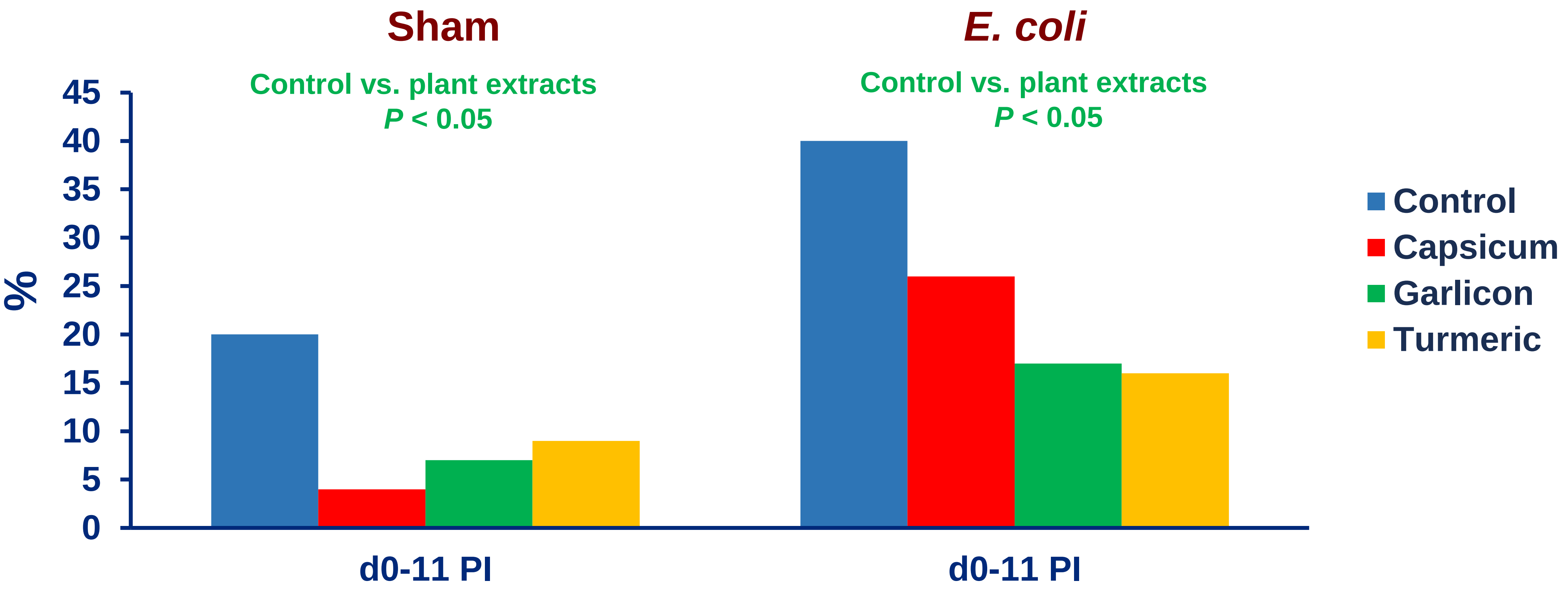
Anti-inflammatory effects - *In vitro*



LPS-stimulated porcine alveolar macrophages

Liu et al., 2012

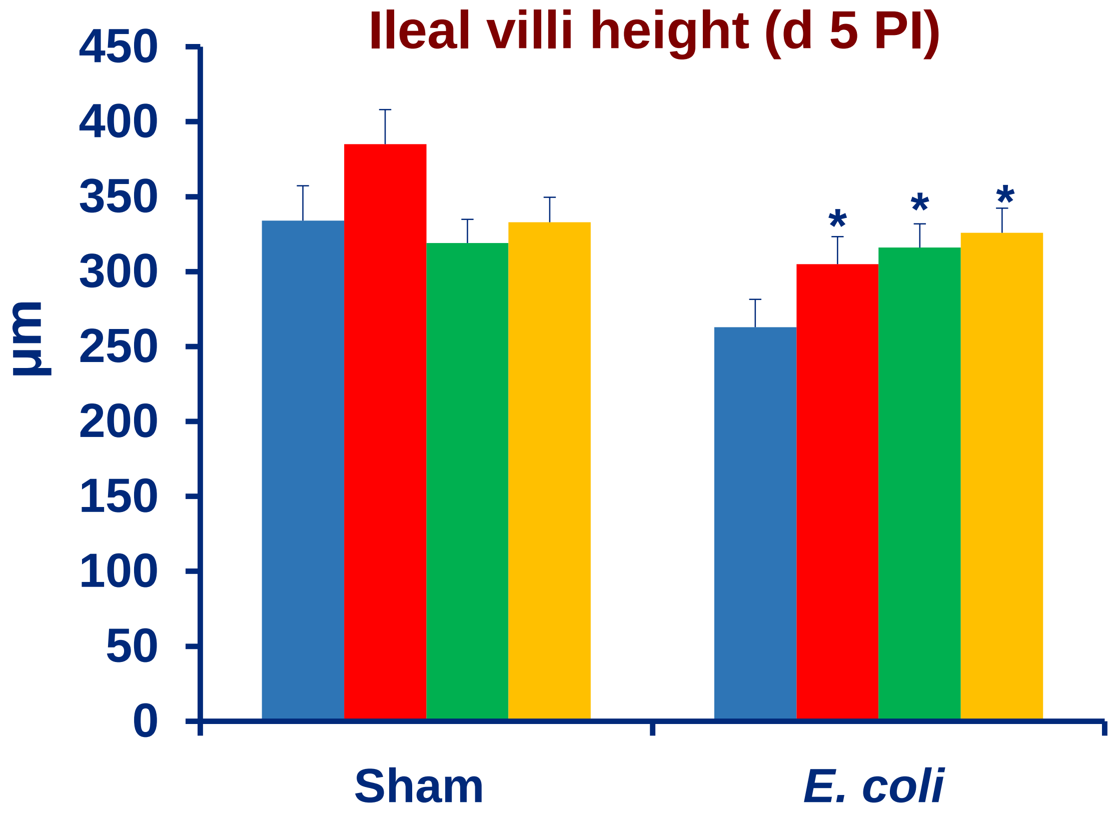
Frequency of diarrhea

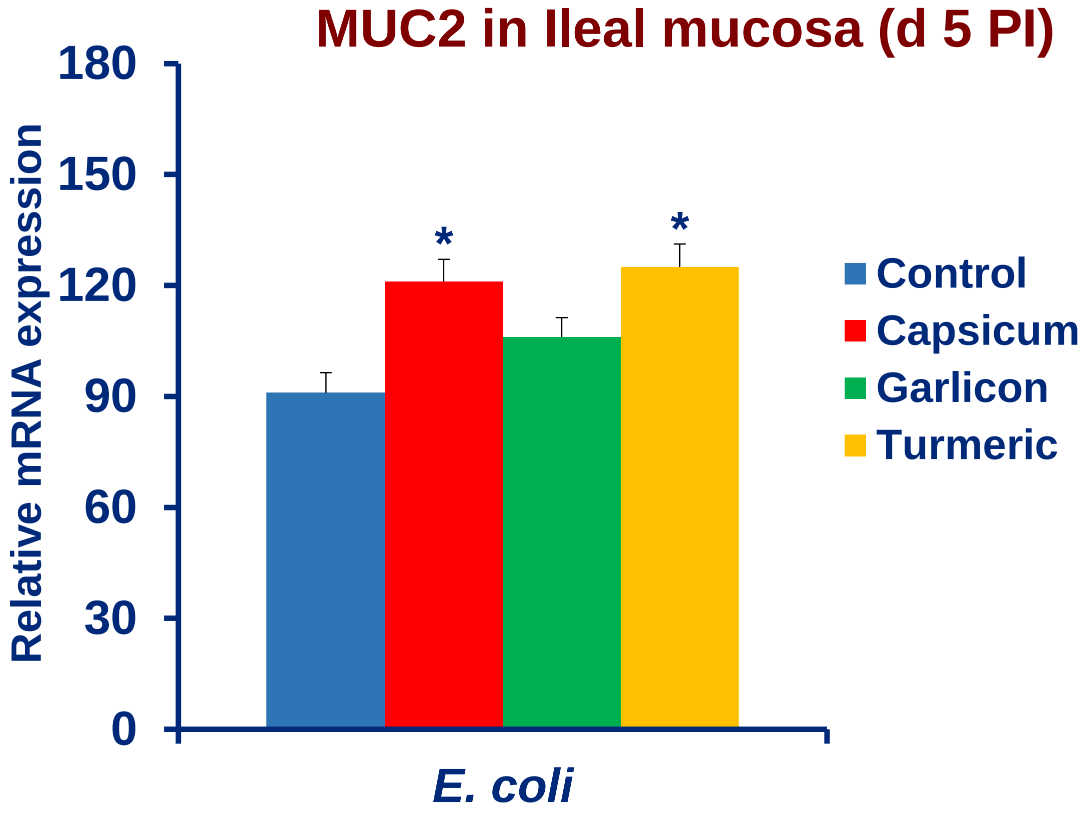


Pig days with diarrhea score ≥ 3
1, normal; 5, watery diarrhea

Liu et al., 2013

Possible mechanisms for reduced diarrhea



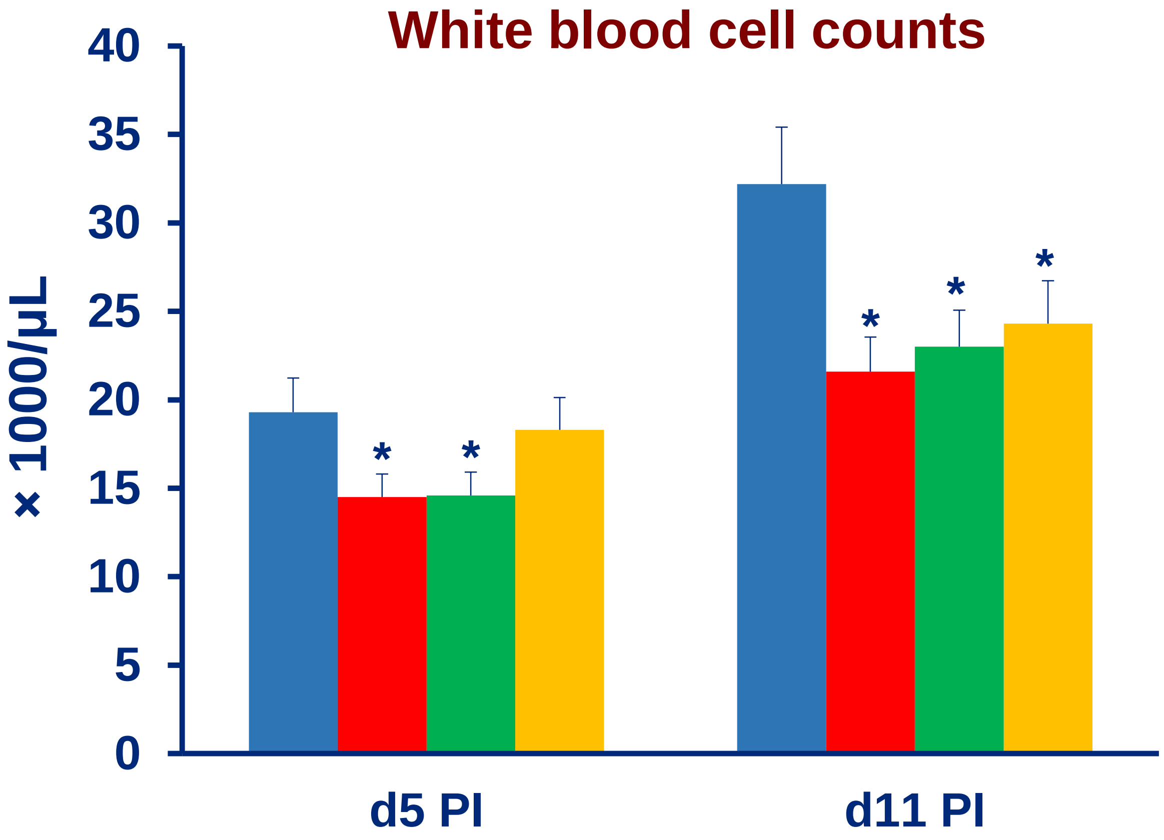


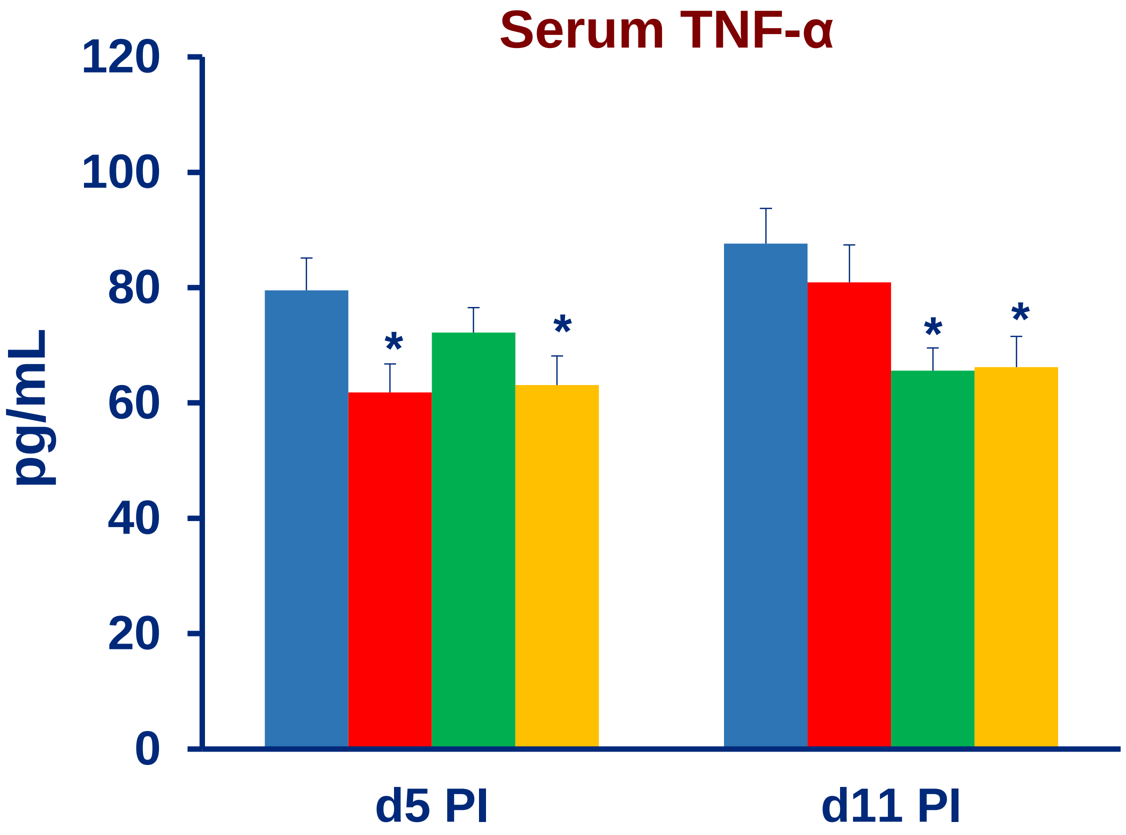
- ➢ **Possibly improved gut barrier function!**

***P* < 0.05**

Liu et al., 2013, 2014

Plant extracts reduced systemic inflammation caused by *E. coli* infection





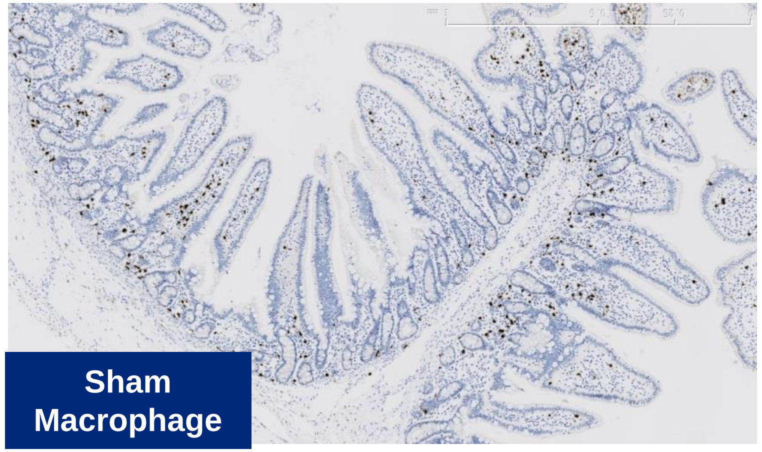
Control Capsicum Garlicon Turmeric

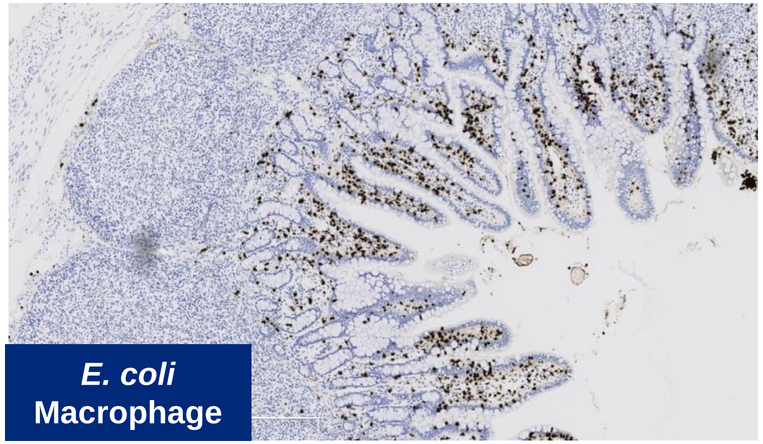
*$P < 0.05$

Liu et al., 2013

UCDAVIS

Plant extracts reduced gut inflammation caused by *E. coli* infection





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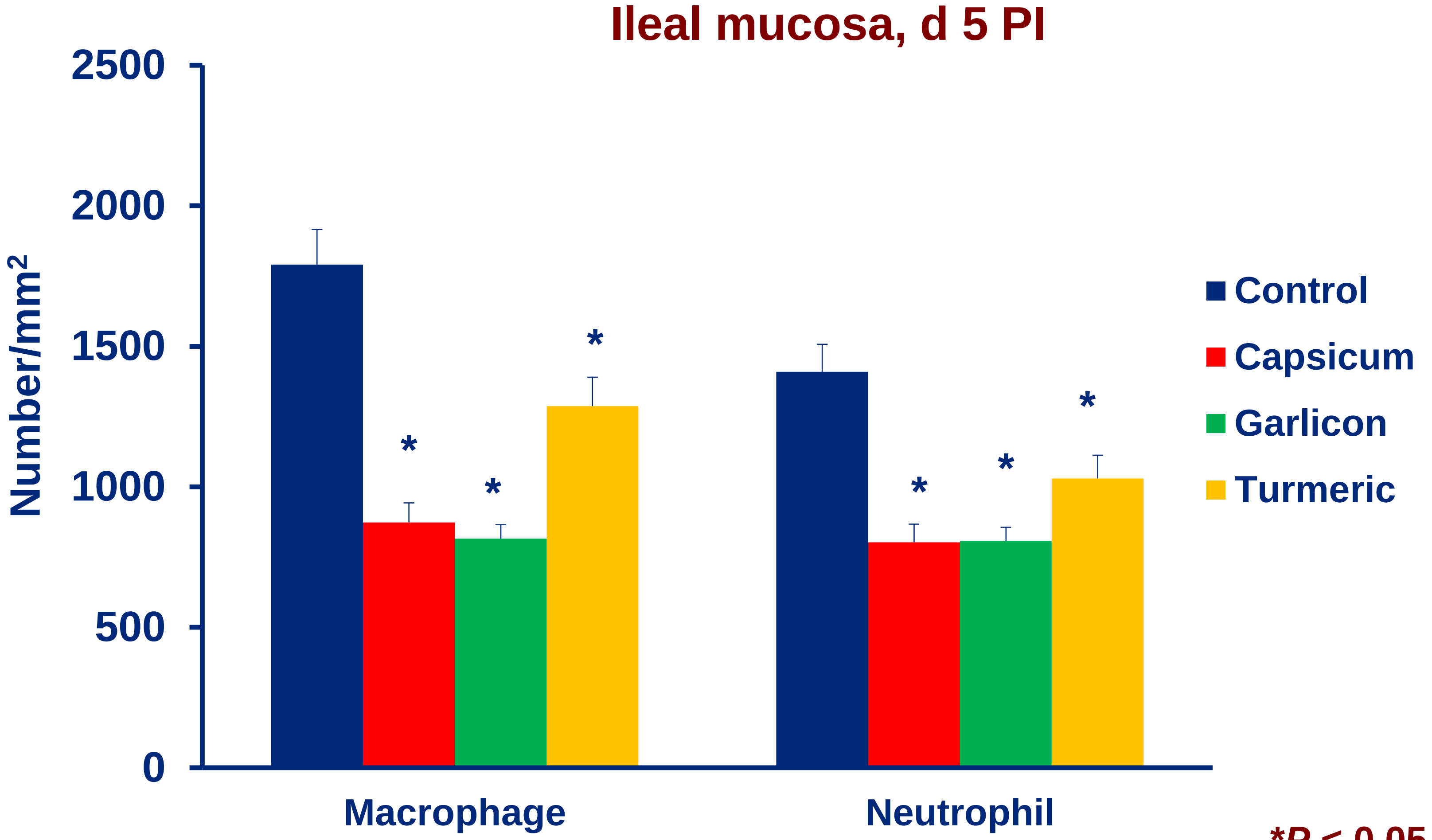

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Liu et al., 2013

UCDAVIS

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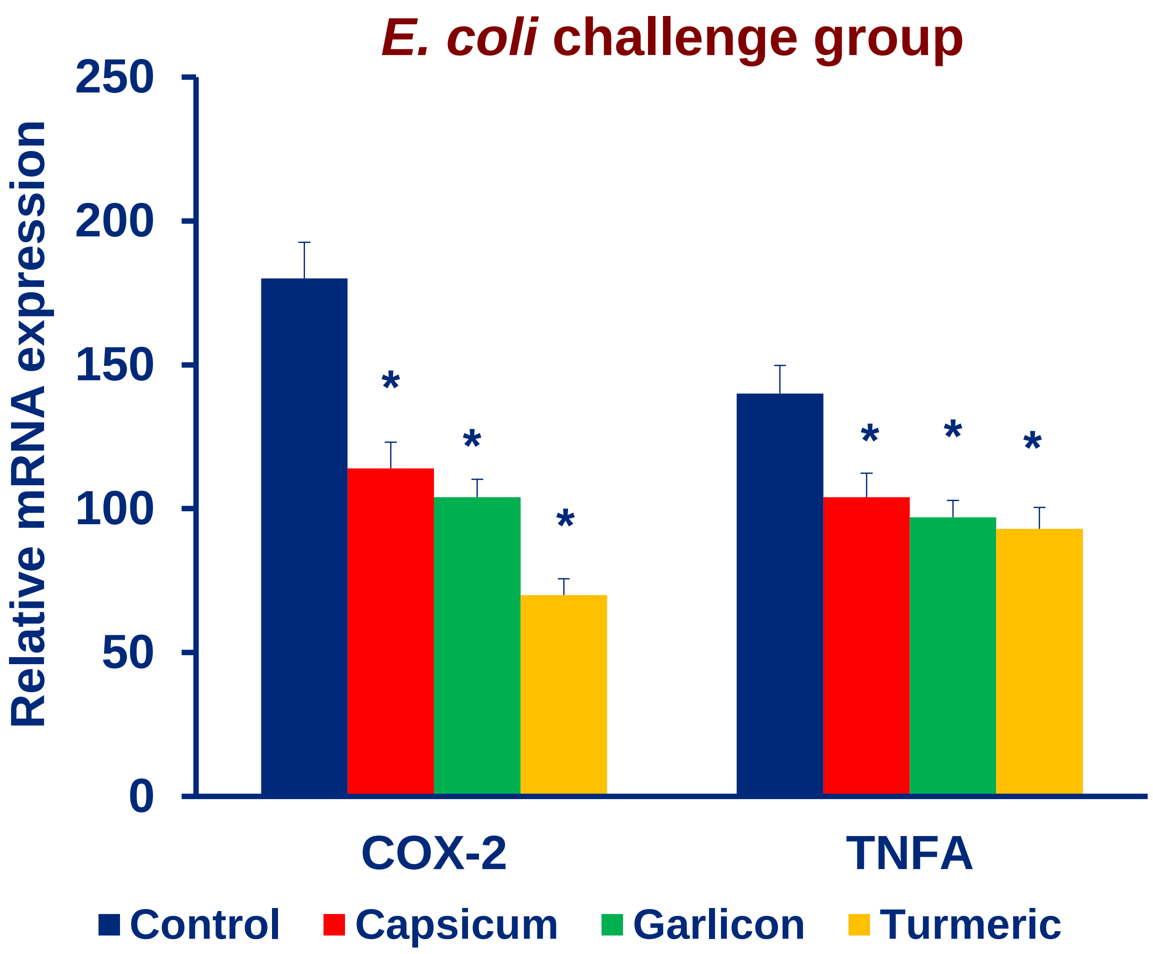
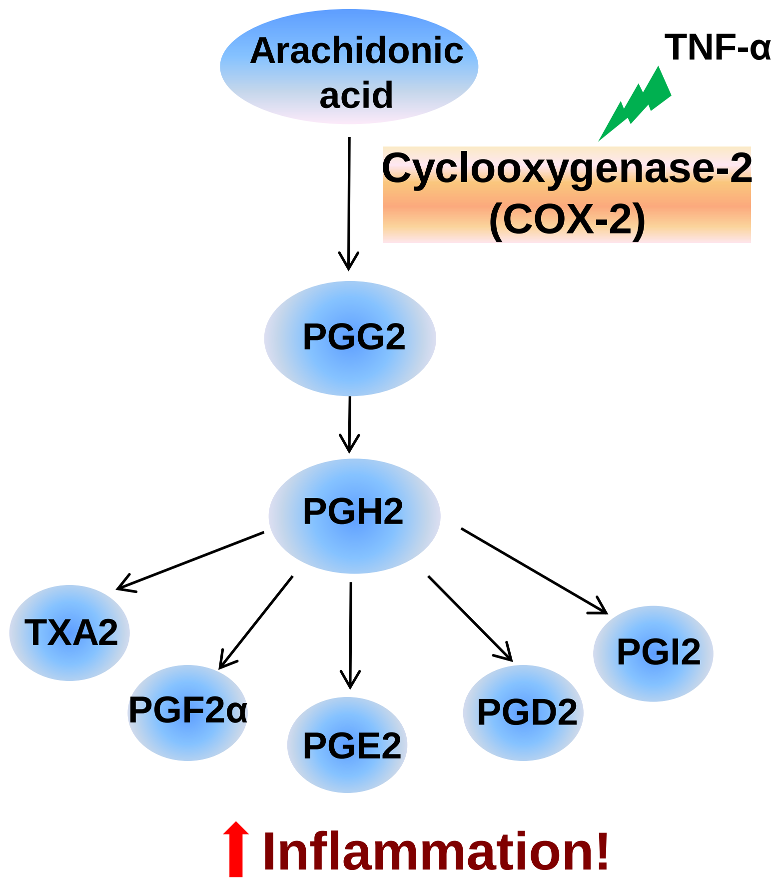


The Prostaglandin Pathway



Liu et al., 2014

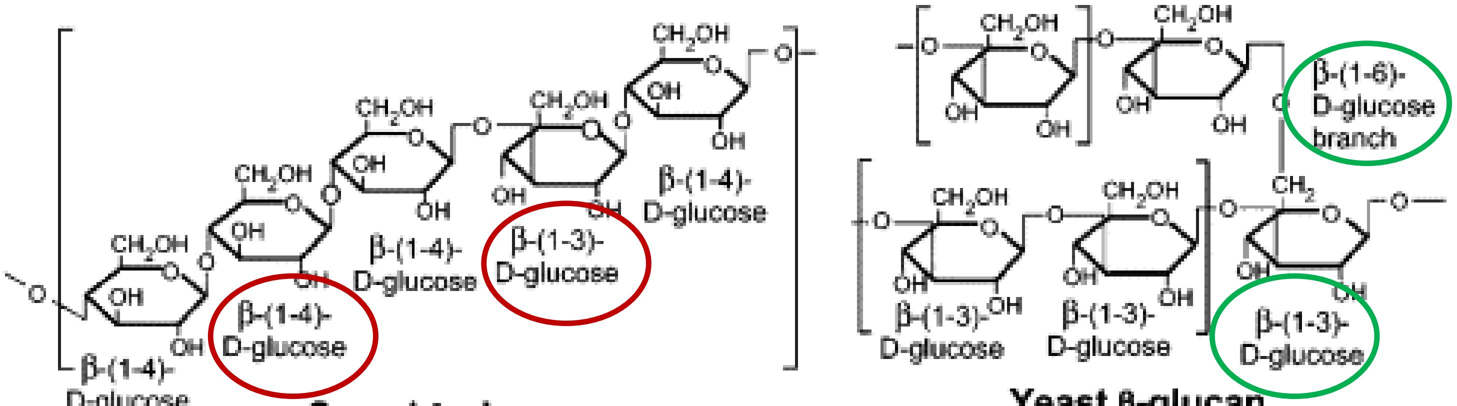
Summary

Anti-inflammatory effects of plant extracts

- **Suppressed the production of inflammatory mediators *in vitro***
- **Reduced diarrhea and enhanced disease resistance of weaning pigs**
- **Possible mechanisms**
  - **Gut barrier function**
  - **Gut mucosa immunity**
  - **Systemic immunity**
  - **Reduced oxidative stress ?**
  - **Modified gut microbiome ?**

β-glucan

- **Heterogeneous group of polysaccharides**
- **Naturally present in cereal grains, fungi, yeast, seaweed, and algae**



Cereal β-glucan
Polymer of β-(1-4)-D-glycopyranosyl units separated by single β-(1-3)-D-glycopyranosyl units.

Yeast β-glucan
Polymer of β-(1-3)-D-glycopyranosyl units with branching at β-(1-6)-D-glycopyranosyl units.

β-glucan type	Structure	Description
Bacterial		Linear β1,3 glucan (i.e.Curdlan)
Fungal		Short β1,6 branched, β1,3 glucan (i.e. Schizophyllan)
Yeast		Long β1,6 branched, β1,3 glucan (i.e. WGP β-glucan, Betafectin™)
Cereal		Linear β1,3/β1,4-glucan (i.e. oat, barley, rye)

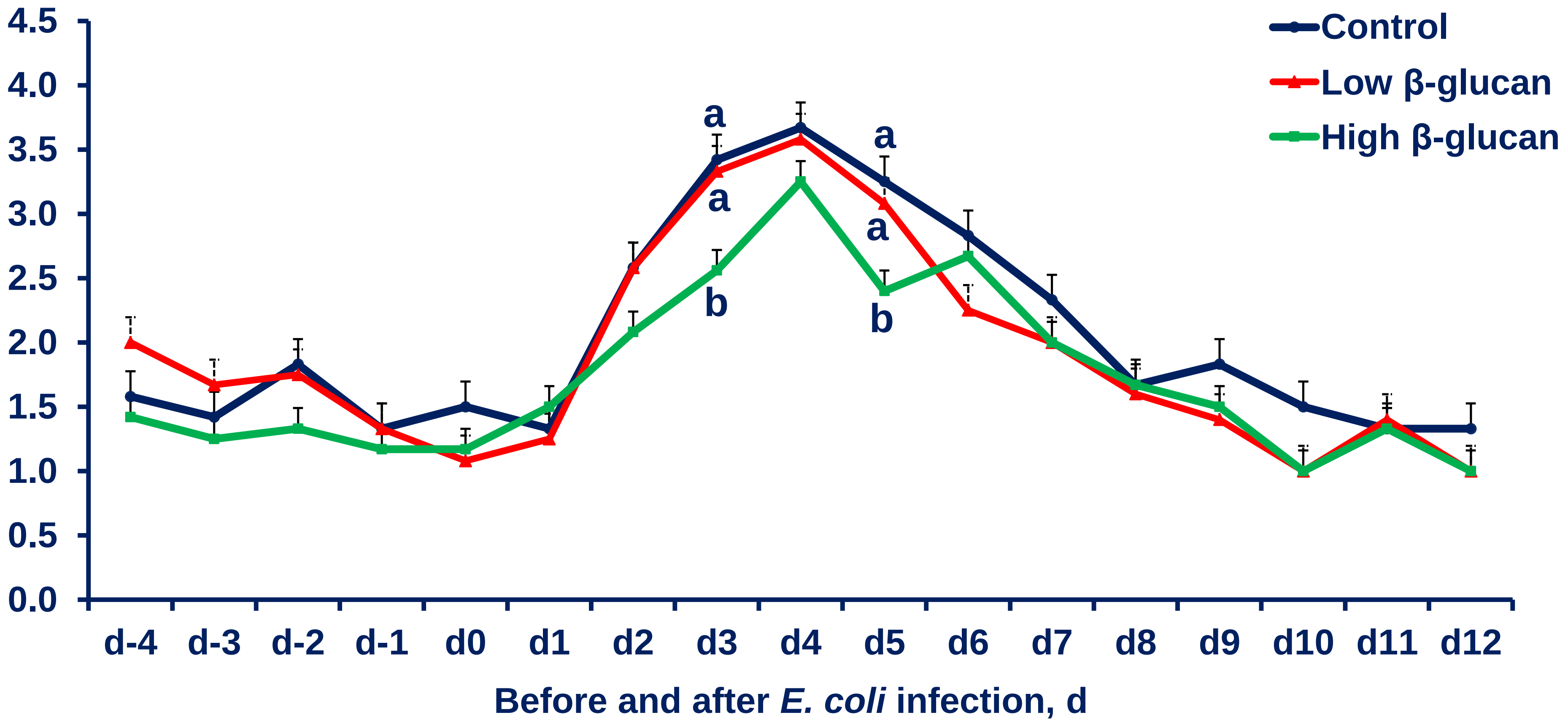
Volman et al., 2008

Algae-derived β-glucan

- Extracted from algae *Euglena gracilis,* a freshwater species of single-celled alga
- Linked by (1,3)-glycosidic bonds and categorized as paramylon
- β-glucan from algae *Euglena gracilis* strongly stimulated porcine leukocytes in vitro

Sonck et al., 2010

Daily diarrhea score

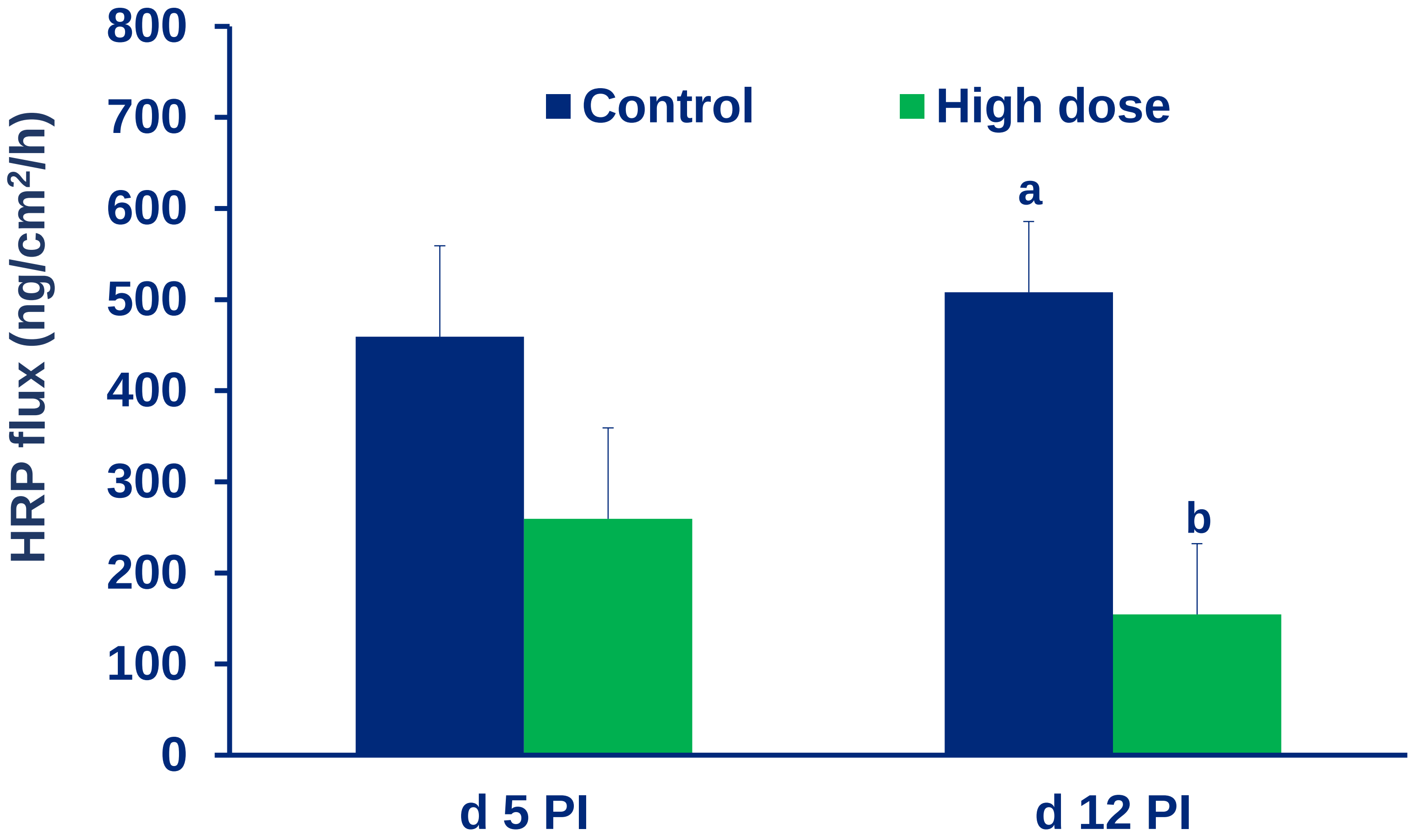


Low = 54 mg/kg β-glucan in Control; High = 108 mg/kg β-glucan in Control

Diarrhea score: 1, normal feces, 2, moist feces, 3, mild diarrhea, 4, severe diarrhea, 5, watery diarrhea

Kim et al., 2019

Transcellular permeability



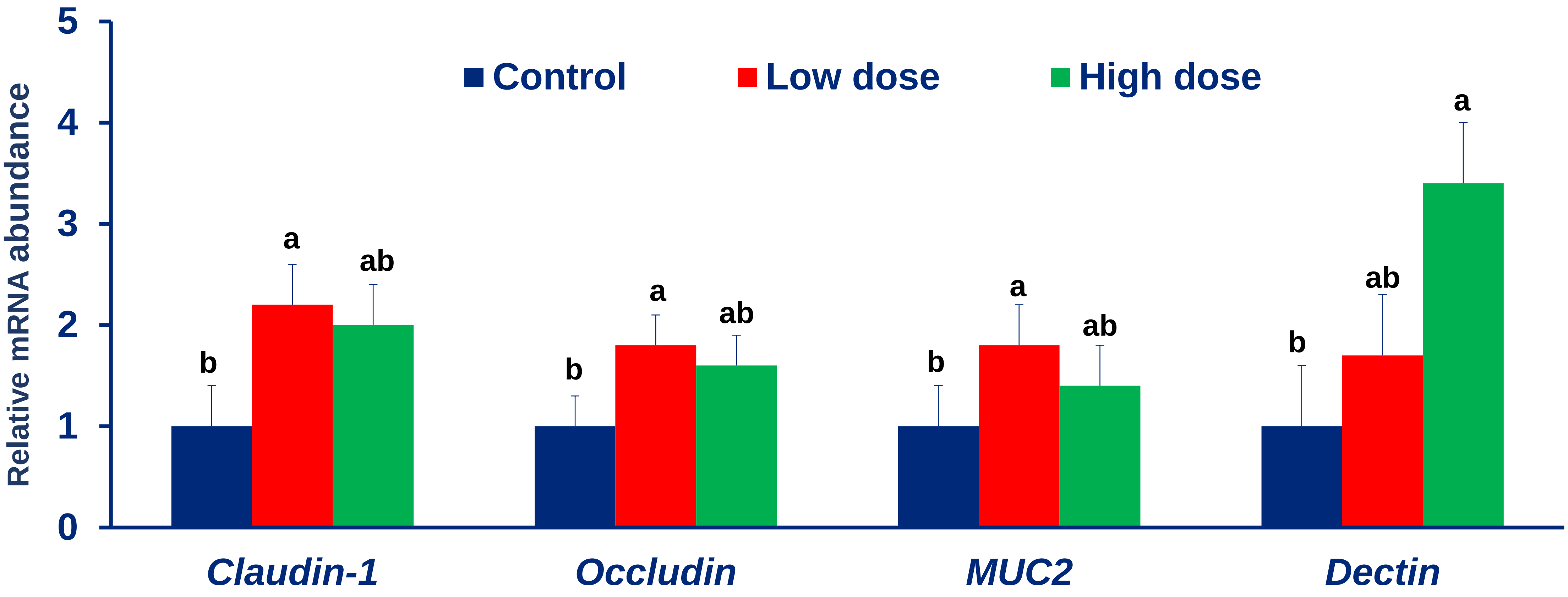
Ussing Chamber

High = 108 mg/kg β-glucan in Control

Kim et al., 2019

Tight junction protein

Gene expression in jejunal mucosa, d 12 PI



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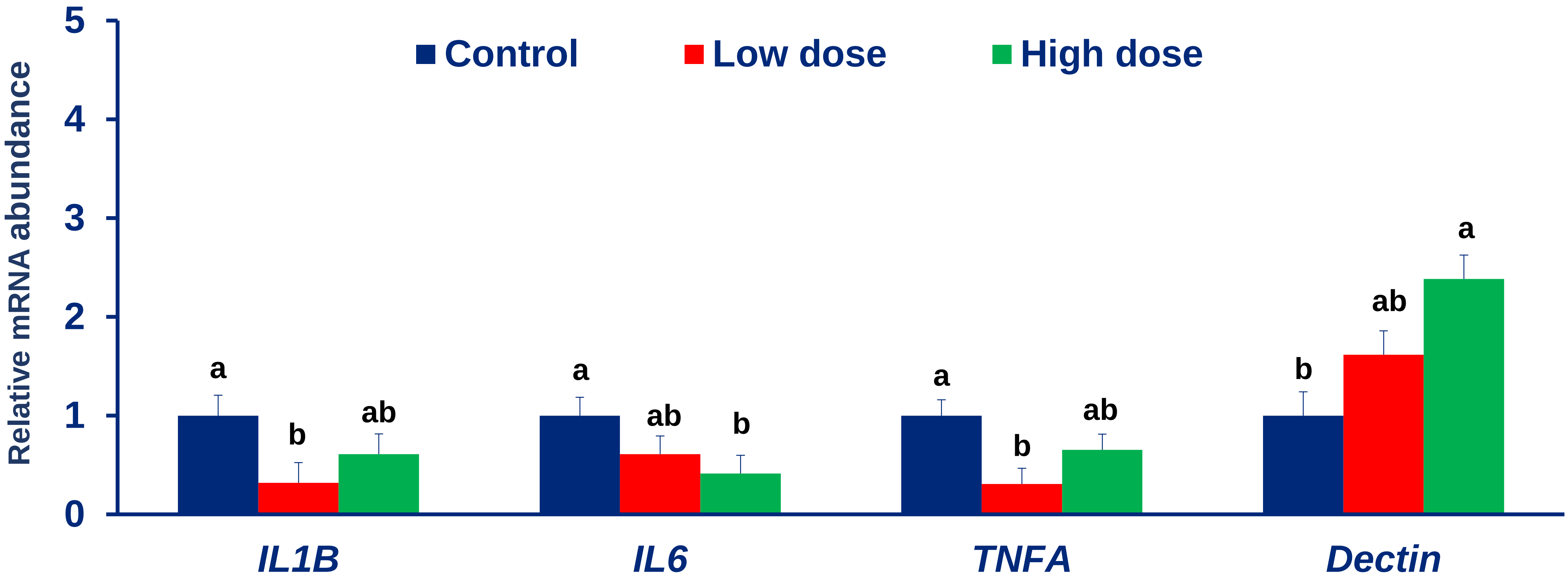
Kim et al., 2019

Intestinal immunity

Gene expression in ileal mucosa, d 12 PI



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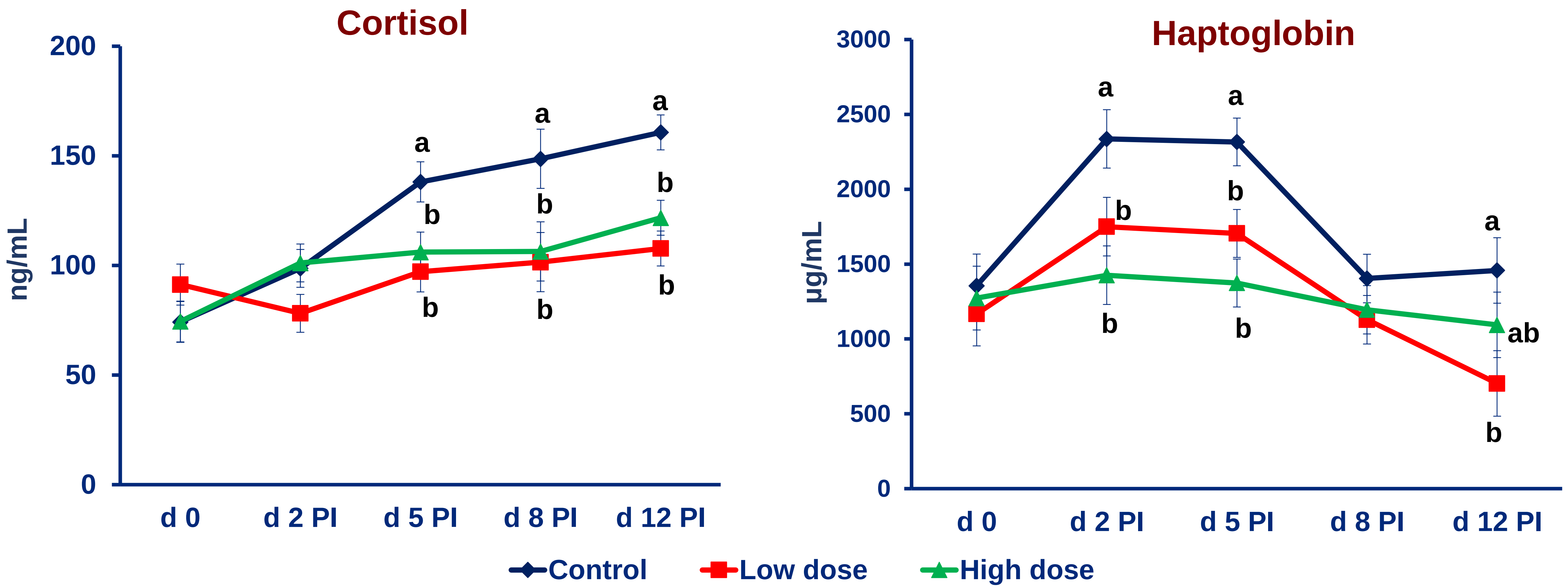
Kim et al., 2019

Serum cortisol and haptoglobin



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Kim et al., 2019

Summary

Protective effects of algae-derived β-glucan

- Dietary supplementation of 108 mg/kg of algae-derived β-glucan alleviated diarrhea of F18 *E. coli* infected pigs
  - Enhanced gut integrity
  - Boosted host immune response
  - Stimulated T-cell activation

Take home message

A healthy gut is extremely important for weanling pigs

- Nutrient digestion & absorption

  Waste excretion
- Functional and protective gut barrier
- Stable & appropriate microbial community
- Functional and protective gut immunity

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WIFSS at UC Davis

- Dr. Xunde Li

Pancosma just makes sense

EVONIK POWER TO CREATE

FEED ADDITIVES AMERICAS 2019