

# Dietary *Bacillus subtilis* enhances disease resistance and intestinal health of weaned pigs

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Abstract No. P092



## Introduction

- Enterotoxigenic *Escherichia coli* (ETEC) is the most common pathotype that causes diarrhea in post-weaning piglets.
- Supplementation of *Bacillus spp.* probiotics reduces incidence of diarrhea and improves growth performance of post-weaning pigs (Bhandari et al., 2008; Hu et al., 2014).
- Probiotics reduced incidence of diarrhea, improved gut barrier integrity, and reduced systemic inflammation of weaned pigs (Kim et al., 2019).

## Objective

- To investigate the effects of supplementation of *Bacillus spp.* probiotics on the growth performance, diarrhea, and intestinal health of weaned pigs experimentally infected with an enterotoxigenic F18 *E. coli*

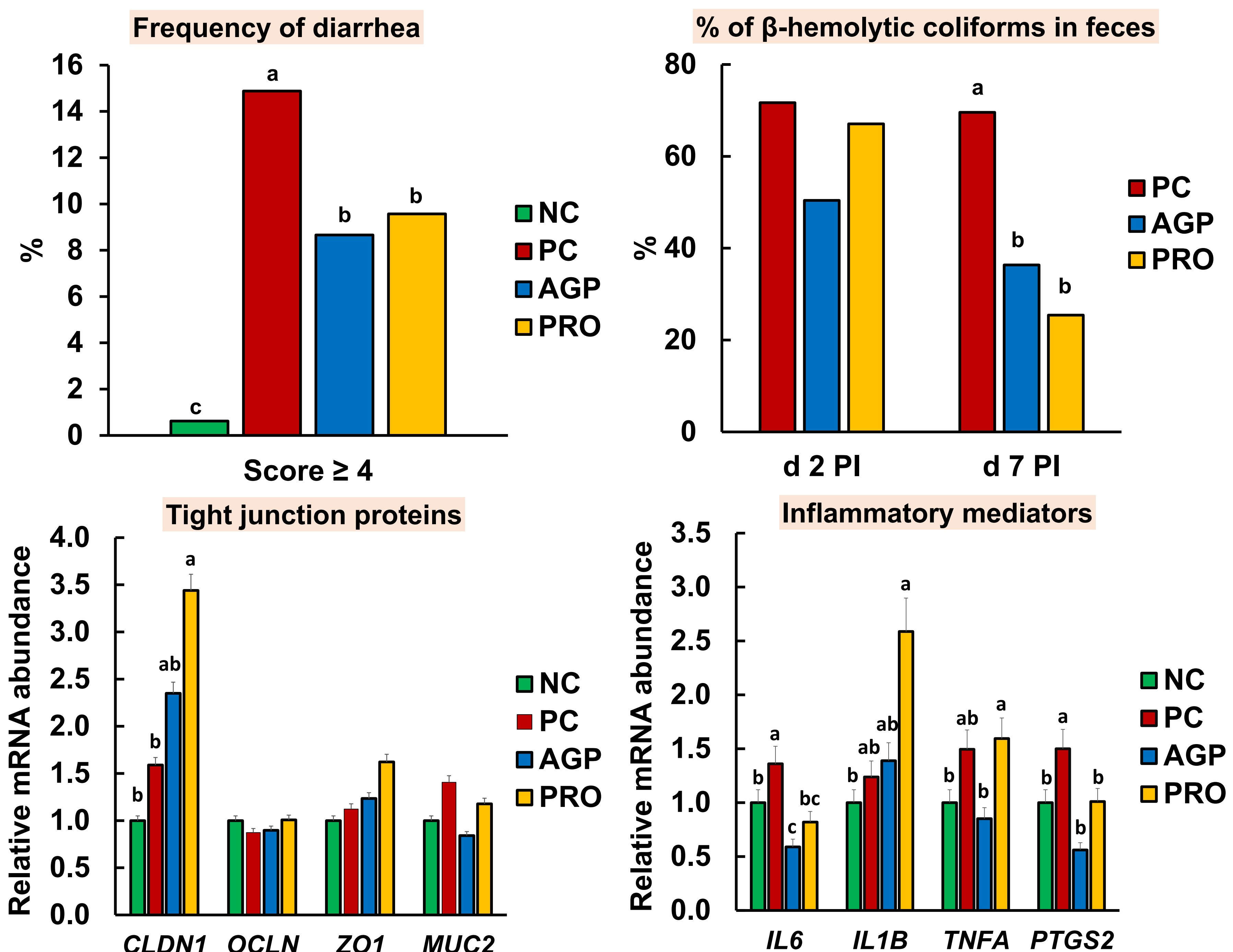
## Materials and Methods

- Animals:** 48 weanling pigs (21 day, 6.17 ± 0.36 kg)
- F18 *E. coli* challenge**
  - Enterotoxigenic F18 *E. coli* (LT, STb, SLT-2)
  - Oral inoculation, 10<sup>10</sup> cfu/dose with 3 doses
- Experimental design**
  - Randomized Complete Block Design
  - Blocking factors: body weight x gender
  - Experimental period: 28 days, 7-day adaptation and 21-day after first *E. coli* inoculation
- Dietary treatments:** 12 pigs/treatment
  - Nursery basal diet without *E. coli* challenge (NC)
  - Nursery basal diet with *E. coli* challenge (PC)
  - PC + 50 mg/kg carbadox (AGP)
  - PC + 500 mg/kg *Bacillus spp.* (PRO)
- Data collection**
  - Growth performance: body weight, average daily gain, average daily feed intake, Gain:Feed
  - β-hemolytic coliforms in feces: d 0 before inoculation and d 3, 7, 14, and 21 post-inoculation (PI)
  - Daily diarrhea score: ranging from 1 to 5 (1, normal feces and 5, watery diarrhea)
  - Jejunum mucosa: mRNA expression of tight junction proteins [claudin 1 (*CLDN1*), Occludin (*OCLN*), Zonula occludens-1 (*ZO1*), mucin 2 (*MUC2*)]
  - Ileal mucosa: mRNA expression of inflammatory mediators [*IL1B*, *IL6*, *TNFA*, cyclooxygenase 2 (*PTGS2*)]
- Data analysis**
  - PROC MIXED of SAS
  - Diet as the main effect and blocks as random effects
  - Experimental unit: pig

## Results

Table 1. Growth performance of weaned pigs

Item	NC	PC	AGP	PRO	SEM	P-value
Body weight, kg						
d 0 PI	7.03	7.17	7.28	7.04	0.43	0.78
d 7 PI	8.78 <sup>b</sup>	8.53 <sup>b</sup>	9.80 <sup>a</sup>	8.56 <sup>b</sup>	0.48	<0.05
d 14 PI	12.55 <sup>ab</sup>	10.56 <sup>c</sup>	13.84 <sup>a</sup>	12.07 <sup>bc</sup>	0.70	<0.05
d 21 PI	17.23 <sup>ab</sup>	13.69 <sup>c</sup>	18.79 <sup>a</sup>	16.46 <sup>b</sup>	0.99	<0.01
Average daily gain, g						
d 0 to 7 PI	250 <sup>b</sup>	212 <sup>b</sup>	359 <sup>a</sup>	218 <sup>b</sup>	28.5	<0.01
d 7 to 14 PI	540 <sup>ab</sup>	459 <sup>b</sup>	594 <sup>a</sup>	501 <sup>ab</sup>	52.7	0.08
d 14 to 21 PI	668 <sup>a</sup>	466 <sup>b</sup>	718 <sup>a</sup>	628 <sup>a</sup>	44.2	<0.01
d 0 to 21 PI	486 <sup>ab</sup>	347 <sup>c</sup>	558 <sup>a</sup>	449 <sup>b</sup>	36.0	<0.01
Average daily feed intake, g						
d 0 to 7 PI	374 <sup>b</sup>	435 <sup>ab</sup>	497 <sup>a</sup>	403 <sup>b</sup>	22.6	<0.05
d 7 to 14 PI	746 <sup>ab</sup>	687 <sup>b</sup>	895 <sup>a</sup>	751 <sup>ab</sup>	66.4	0.10
d 14 to 21 PI	1,070 <sup>b</sup>	822 <sup>c</sup>	1,306 <sup>a</sup>	1,029 <sup>b</sup>	76.6	<0.01
d 0 to 21 PI	730 <sup>b</sup>	647 <sup>b</sup>	899 <sup>a</sup>	728 <sup>b</sup>	57.5	<0.01
Gain:Feed						
d 0 to 7 PI	0.68 <sup>ab</sup>	0.49 <sup>c</sup>	0.73 <sup>a</sup>	0.54 <sup>bc</sup>	0.059	<0.05
d 7 to 14 PI	0.72 <sup>a</sup>	0.59 <sup>b</sup>	0.68 <sup>ab</sup>	0.67 <sup>ab</sup>	0.039	0.07
d 14 to 21 PI	0.62	0.61	0.56	0.61	0.030	0.50
d 0 to 21 PI	0.66 <sup>a</sup>	0.53 <sup>b</sup>	0.63 <sup>a</sup>	0.62 <sup>a</sup>	0.023	<0.01



## Conclusions

- Supplementation of *Bacillus subtilis* in pig feed
  - Improved growth performance and disease resistance
  - Alleviated diarrhea, reduced intestinal inflammation, and enhanced gut barrier function

## References

- Bhandari, S. K., Xu, B., Nyachoti, C. M., Giesting, D. W., and Krause, D. O. 2008. Evaluation of alternatives to antibiotics using an *Escherichia coli* K88+ model of piglet diarrhea: Effects on gut microbial ecology. *Journal of Animal Science*. 86:836-847.
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This research was supported by the National Pork Board grant #18-081