Improving feed efficiency and gut integrity of E. coli-challenged weaned pigs

Public concern over potential antibiotic resistance risks related to human health has driven interest in nursery pig nutrition and the adoption of antibiotic-free feeding systems. This has led to the development of feed additives that can be used as in-feed antibiotic alternatives in pig feeding strategies.

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Probiotics are among the key alternative solutions to antibiotics and are defined as live micro-organisms which, when administered in adequate amounts, confer a health benefit on the host.

Post-weaning diarrhoea is a major challenge and more severe during the first two weeks after weaning in pigs. Therefore, development of feeding strategies to manage the gut health of pigs during this period is critical. One of the models to mimic the conditions of post-weaning diarrhoea for evaluation of gut health feed additives is to expose susceptible pigs to enterotoxigenic E. coli.

A study from the South Dakota State University, USA, showed that supplementing a probiotic (Bacillus subtilis DSM 32540; GutPlus) in weaned pig diets can significantly improve gain:feed efficiency, gut health and faecal consistency score of post-weaned pigs challenged with enterotoxigenic E. coli K88.

Experimental design

A total of 21 crossbred pigs (initial body weight (BW) of 8.21 ± 0.81kg and weaned at 21 days of age were individually housed in pens, and fed three experimental diets:

- A corn-soybean meal (SBM) basal diet without antibiotics (negative control; NC).
- The basal diet with antibiotic growth promoters (AGP; 0.25% neomycin + oxytetracycline) (positive control; PC).
- The basal diet supplemented with 0.05% GutPlus (Bacillus subtilis 32540).

The diets were adequate in all nutrients (NRC, 2012) and fed ad libitum for 21 days. The dietary treatments began on day -3, and on day 0 all pigs were orally challenged with a sub-clinical dose (6.7×10^8 CFU/ml) of K88 strain E. coli.

After E. coli challenge, the pigs were further monitored for 18 days to evaluate post-infection performance, such as average daily feed intake (ADFI), average daily gain (ADG), and gain to feed ratio (G:F).

The occurrence and severity of post-weaning diarrhoea were assessed daily throughout the study by using a faecal consistency scoring system:

- 1 = firm faeces.
- 2 = soft faeces.

- 3 = mild pasty diarrhoea.
- 4 = pasty diarrhoea.
- 5 = watery diarrhoea and dehydration.
- 6 = massive dehydration and death without apparent diarrhoea.

Furthermore, the morphology, pH and short chain fatty acid (SCFA) concentration in jejunum and ileal tissue were evaluated.

Experimental results

The growth performance results of before and after E. coli k88 challenged weaned pigs are presented in Table 1.

There was no effect of treatments in BW before or after E. coli challenge. Likewise, overall ADG, ADFI, and G:F were not affected by treatment considering the total 21-day experimental period (three days before and 18 days after the E. coli challenge).

However, considering only the period of E. coli challenge from day 0-18, there was an increase in G:F with AGP and GutPlus treatment compared to the NC group, while no difference between AGP and Bacillus subtilis 32540 was observed. In addition, two out of seven pigs receiving the NC diets died one or two days after the E. coli challenge and the autopsy confirmed that the cause of death was a consequence of the E. coli challenge.

The faecal score increased after the oral inoculation of E. coli on day 0, and gradually reduced until day 12 to the same lowest faecal score (1) observed before the challenge.

The proportion of the faecal scores in each treatment during the whole trial is presented in Fig. 1. Pigs that were supplemented with AGP or GutPlus tended (P = 0.07) to show reduced frequency of diarrhoea (scores 3-6) compared to pigs fed NC diets (Fig. 2).

Gut histomorphology

Data on the effect of diets on small intestinal histomorphology (day 18) is shown in Table 2.

In the jejunum, pigs fed diets supplemented with GutPlus had the

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Fig. 1. Effect of supplementation of AGP or GutPlus on the proportion of faecal scores during 21 days.

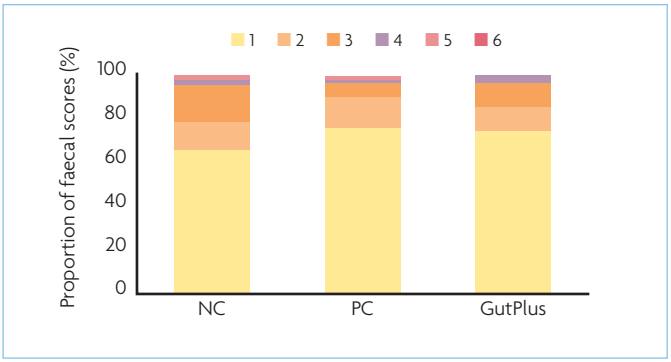
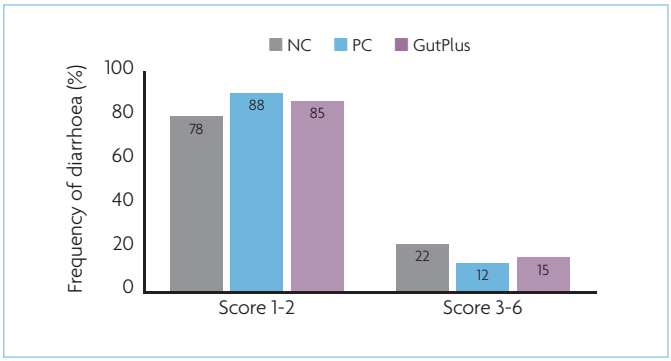


Fig. 2. Effect of supplementation of AGP or GutPlus on the frequency of diarrhoea during 21 days.



Parameter	NC	PC (antibiotic)	GutPlus	SEM	*P*-value
Overall					
ADG (d -3-18) (g)	283	288	310	50	0.908
ADFI (d -3-18) (g)	429	378	403	50	0.732
G:F (d -3-18)	0.65	0.74	0.77	0.04	0.137
Challenge period					
ADG (d 0-18) (g)	308	333	347	48	0.858
ADFI (d 0-18) (g)	483	421	448	53	0.722
G:F (d 0-18)	0.63b	0.78a	0.79a	0.03	0.010
Mortality (%)	25	0	0	–	–

[a,b] Within a row, means without a common superscript differ (P<0.05).
NC = Negative control (basal diet), PC = Positive control (basal diet supplemented with antibiotics), GutPlus = Probiotic diet (basal diet supplemented with Bacillus subtilis 32540).

Table 1. The effects of dietary inclusion of antibiotic or probiotic on the performance of piglets under E. coli k88 challenge.

Diet	Jejunum			Ileum		
	Villus height	Crypt depth	VH:CD	Villus height	Crypt depth	VH:CD
NC	305[c]	177	172[c]	298	170	198
PC (antibiotic)	406[b]	177	229[b]	389	164	264
GutPlus	435[a]	182	240[a]	437	171	253
SEM	2.13	2.86	3.71	42.77	16.18	26.06
P-value	<0.001	0.472	<0.001	0.095	0.951	0.182

[a,b,c] Within a column, means without a common superscript differ (P<0.05).
NC = Negative control (basal diet), PC = Positive control (basal diet supplemented with antibiotics), GutPlus = probiotic diet (basal diet supplemented with Bacillus subtilis 32540).

Table 2. Effects of the dietary inclusion of antibiotic or probiotic on the morphology of jejunum and ileum of piglets under E. coli k88 challenge (day 18).

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greatest (P<0.001) villus height (VH) and villus height to crypt depth ratio (VH:CD) among treatments.

Pigs fed diets supplemented with AGP had greater (P<0.001) VH and VH:CD than NC pigs, but less than pigs receiving GutPlus.

No difference was observed in crypt depth (CD) among treatments. In ileum, no effects of treatments were observed in CD or VH:CD, but the GutPlus tended (P=0.095) to increase VH at a greater extent than AGP compared to NC pigs. In addition, there were no differences observed in organ weights (data not shown).

pH and short chain fatty acid

Ileal pH tended (P=0.08) to decrease when diets were supplemented with AGP (6.0) or Bacillus subtilis 32540 (6.3) compared to the NC diet (6.6). However, caecal pH was not different among NC (5.6), AGP (5.7), and GutPlus (5.5). The effects of dietary treatment on SCFA of caecal digesta. The quantitative values of SCFA and total SCFA amount were not affected by dietary treatment (data not shown).

Likewise, the proportion of most SCFA as percentage of total SCFA was not affected by treatments with the exception of valeric acid which was reduced (P<0.05) by AGP compared to NC, but was not different from the treatment with GutPlus.

Overall, supplementation with GutPlus (Bacillus subtilis 32540) or AGP in weaned pig diets significantly improved gain:feed efficiency and gut health parameters (reduction of diarrhoea, improved gut morphology, reduction of ileal pH) under E. coli challenge.

Therefore, under E. coli challenge, the probiotic GutPlus may replace the use of antibiotics as a growth promoter in diets for weaned pigs to improve feed efficiency and gut integrity. ■

References are available from the authors on request