Effects of antibacterial peptides in non-antibiotic feeds on the productivity of growing pigs

Phuong T. H. To*, & Dong D. Duong
Department of Animal Nutrition, Nong Lam University, Ho Chi Minh City, Vietnam

ARTICLE INFO

Research Paper

Received: August 12, 2024
Revised: September 12, 2024
Accepted: October 04, 2024

Keywords

Antibacterial peptides
Antibiotics
Growing pigs
Organic compounds

***Corresponding author**

To Thi Hong Phuong
Email:
phuong.tothihong@hcmuaf.edu.vn

ABSTRACT

The objective of this study was to evaluate growth performance of finishing pigs fed diets with two antibiotics or fed with organic-originated supplements. A total of 48 crossbred weaned piglets were randomly assigned into four treatments and the study was conducted in 108 days. Each treatment had 06 replicates and 2 piglets (1 male and 1 female) per replicate. Those organic-originated supplements included phytogenic extracts, organic acid, probiotics or new preparation of anti-bacterial peptides (trade name Halor Tid). The treatment I: pigs were only fed basal diet without antibiotics supplements or other organics feed additives (Negative control). Treatment II: pigs were fed with two antibiotics including colistin 1% and BMD 10% in order to prevent *E. coli* and *Clostridium perfringens* infection (Positive control). Pigs in treatment III were fed with a combination of phytogenic extracts, organic acid and probiotics whereas pigs in treatment IV were fed with a combination of phytogenic extracts, organic acid and anti-bacterial peptides. The results showed that the performance parameters such as body weight gain, feed conversion ratio (FCR) and issues of diarrhea and mortality were the worst in the treatment I; whereas these performance parameters in the treatment III or in treatment IV were better than those in treatment II although this difference was not statistically significant at $P > 0.05$. Besides, the feed cost per kg of live weight of pigs in treatment III and treatment IV was significantly lower than that in treatment I and II.

Cited as: To, P. T. H., & Duong, D. D. (2024). Effects of antibacterial peptides in non-antibiotic feeds on the productivity of growing pigs. *The Journal of Agriculture and Development* 23(Special issue 2), 63-75.

1. Introduction

Pig feed is often composed of plant extracts, organic acids and probiotics, and previously various antibiotics to enhance pig gut health and thereby improve livestock productivity (Pearlin et al., 2020; Rahman et al., 2022). Recently, feed is added preparations holding antimicrobial peptides have been introduced for use in combination with natural preparations to better enhance intestinal health in pigs (Silveira et al., 2021). Wang et al. (2019) showed the role of antimicrobial peptides against the effects of Gram-negative bacteria, Gram-positive bacteria and enhancing the role of the immune system to help animals stay healthy and increase productivity. According to research by Xiao et al. (2015) and Xu et al. (2020), products supplemented with anti-bacterial peptides have the effect of replacing antibiotics in destroying harmful intestinal bacteria and enhancing intestinal health in pigs.

This trial was conducted to evaluate performance of growing pigs as being fed diets which are contain only two kinds of antibiotics or no antibiotics but supplemented of organic materials to enhance gut health status such as combination of phytogenic, organic acid and probiotics or combination of phytogenic, organic acids and a new preparation of anti-bacterial peptides (trade name Halor Tid).

2. Materials and Methods

The trial was conducted from July to November 2023 in Nong Lam University, Ho Chi Minh City. A total of 48 crossbred weaned piglets which bodyweight was about 8.00 ± 0.1 kg/pig, were randomly assigned into four treatments. Each treatment had 06 replicates and there were one male and one female piglets per replicate. Twelve pigs in treatment I served as negative control group, which were fed basal diet with no supplementation of antibiotics or other organics feed additives. Treatment II was positive control, pigs were fed with two antibiotics including Colistin 1% and BMD 10% in order to prevent *E.coli* and *Clostridium perfringens* infection. Pigs in treatment III were fed basal diet like the one of treatment I but supplemented with a combination of phytogenic extracts, organic acid and probiotics as means of enhancing of gut health status; and pigs in treatment IV was fed similar diet of treatment III but the probiotics preparation supplemented was replaced by the anti-bacterial peptides with trade name Halor Tid. The experimental is showed in Table 1.

Table 1. Experimental design

Treatment	Feed + Experimental factors	Replicates	Number of pig
I	Basal feed	6	12
II	Basal feed + Colistin 1% + BMD 10%	6	12
III	Basal feed + Phytogenic + Organic acid + Probiotics	6	12
IV	Basal feed + Phytogenic + Organic acid + Halor Tid	6	12

Colistin 1 % was used at dose 0.5 kg/ton of feed for whole stages; BMD 10% was used at dose 0.3 kg/ton of feed for whole stages; Phytogenic was administered at a dose of 0.5 kg/ton of feed in period 7 – 40 kg and 0.4 kg/ton of feed in period 40 kg - finish; Organic acid was used at a dose of 2 kg/ton of feed in period 7 – 40 kg and 1 kg/ton of feed in period 40 kg - finish; Probiotics were administered at a dose of 1 kg/ton of feed in period 7 – 40 kg and 0.5 kg/ton in period 40 kg – finish; Halor Tid was administered at a dose of 0.5 kg/ton of feed for whole stages.

Feed formulas for experimental treatments at each farming stage are presented in Tables 2, 4 and 6, and calculated nutritional ingredients are presented in Tables 3, 5 and 7.

Table 2. Pig feed formula for the period 7 - 15 kg and period 15 - 25 kg

Ingredient (%)	Period 7 - 15 kg				Period 15 - 25 kg			
	I	II	III	IV	I	II	III	IV
Grain corn	25.00	25.00	25.00	25.00	53.69	53.69	53.09	53.67
Broken rice	11.35	11.25	10.94	11.00	-	-	-	-
Single-cell protein powder	3.00	3.00	3.00	3.00	1.46	1.46	1.45	1.46
Single-cell protein liquid	4.00	4.00	4.00	4.00	3.86	3.86	3.88	3.85
Rice bran I	10.00	10.00	10.00	10.00	4.98	4.98	5.51	5.01
Fermented soy-beans	12.61	12.63	12.67	12.66	2.70	2.70	2.70	2.70
Cassava residue	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Soybean meal46	10.00	10.00	10.00	10.00	20.00	20.00	20.00	20.00
Meat and bone meal	3.00	3.00	3.00	3.00	-	-	-	-
Lactose	5.00	5.00	5.00	5.00	1.20	1.20	1.20	1.20
Whey	4.00	4.00	4.00	4.00	1.80	1.80	1.80	1.80
Soybean oil	1.49	1.49	1.49	1.49	0.30	0.30	0.32	0.30
Colistin 1%	-	0.05	-	-	-	0.05	-	-
BMD 10%	-	0.03	-	-	-	0.03	-	-
Phytogenics	-	-	0.05	0.05	-	-	0.05	0.05
Organic acid	-	-	0.20	0.20	-	-	0.20	0.20
Probiotics	-	-	0.10	-	-	-	0.10	-
Halor Tid	-	-	-	0.05	-	-	-	0.05
Other Ingredients*	5.55	5.55	5.55	5.55	5.01	4.93	4.70	4.72
Total	100	100	100	100	100	100	100	100

**"Other ingredients" include acid amin, premix, salt, limestone, DCP, enzymes.*

Table 3. Nutrients of feed for the period 7 - 15 kg and period 15 - 25 kg

	Period 7 - 15 kg				Period 15 - 25 kg			
	I	II	III	IV	I	II	III	IV
DM (%)	87.59	87.61	87.64	87,63	86.00	86.00	86.00	86.00
MEg (kcal/kg)	3,236	3,233	3,225	3,226	3,231	3,231	3,230	3,231
CP (%)	21.00	21.00	21.00	21,00	17.95	17.95	17.96	17.95
EE (%)	4.82	4.82	4.82	4,82	3.62	3.62	3.67	3.63
CF (%)	3.54	3.54	3.54	3,54	3.28	3.28	3.33	3.29
Ash (%)	5.18	5.18	5.18	5,19	4.11	4.11	4.14	4.12
Calcium (%)	1.20	1.20	1.20	1,20	0.90	0.87	0.80	0.80
Phosphor total (%)	0.57	0.57	0.57	0,57	0.44	0.44	0.44	0.44
Phosphor available (%)	0.40	0.40	0.40	0,40	0.40	0.40	0.40	0.40
Sodium (%)	0.35	0.35	0.35	0,35	0.17	0.17	0.17	0.17
Chloride (%)	0.53	0.52	0.53	0,53	0.34	0.34	0.34	0.34
dEB	249	249	249	248	200	200	200	200
Lysine SID pig (%)	1.420	1.420	1.420	1,420	1.320	1.320	1.320	1.320
Methionine SID pig (%)	0.606	0.606	0.606	0,606	0.558	0.558	0.558	0.558
Met+Cys, SID pig (%)	0.850	0.850	0.850	0,850	0.790	0.790	0.790	0.790
Threonine SID pig (%)	0.890	0.890	0.890	0,890	0.830	0.830	0.830	0.830
Tryptophan SID pig (%)	0.310	0.310	0.310	0,310	0.290	0.290	0.290	0.290
Valine SID pig (%)	0.970	0.970	0.970	0,970	0.890	0.890	0.890	0.890
Isoleucine SID pig (%)	0.780	0.780	0.780	0,780	0.720	0.720	0.720	0.720

Table 4. Pig feed formula for the period 25 - 40 kg và period 40 - 70 kg

Ingredient (%)	Period 25 - 40 kg				Period 40 - 70 kg			
	I	II	III	IV	I	II	III	IV
Grain corn	54.37	54.37	53.00	53.55	56.40	56.40	56.40	56.37
Single-cell protein powder	0.36	0.36	0.34	0.35	1.35	1.35	1.35	1.35
Single-cell protein liquid	2.81	2.81	2.88	2.84	2.87	2.87	2.87	2.87
Rice bran I	7.32	7.32	8.53	8.05	6.84	6.84	6.85	6.85
Cassava residue	8.00	8.00	8.00	8.00	10.00	10.00	10.00	10.00
Soybean meal46	22.57	22.57	22.54	22.55	17.78	17.78	17.78	17.78
Soybean oil	0.20	0.20	0.24	0.23	0.20	0.20	0.20	0.20
Colistin 1%	-	0.05	-	-	-	0.05	-	-
BMD 10%	-	0.03	-	-	-	0.03	-	-
Phytogenic	-	-	0.05	0.05	-	-	0.04	0.04
Organic acid	-	-	0.20	0.20	-	-	0.10	0.10
Probiotics	-	-	0.10	-	-	-	0.05	-
Halor Tid	-	-	-	0.05	-	-	-	0.05
Other ingredients*	4.40	4.32	4.14	4.15	4.55	4.47	4.36	4.41
Total	100	100	100	100	100	100	100	100

**"Other ingredients" include acid amin, premix, salt, limestone, DCP, enzymes.*

Table 5. Nutrients of feed for the period 25 - 40 kg và period 40 - 70 kg

Treatment	Period 25 - 40 kg				Period 40 - 70 kg			
	I	II	III	IV	I	II	III	IV
DM (%)	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00
MEg (kcal/kg)	3,212	3,212	3,210	3,211	3,158	3,158	3,158	3,158
CP (%)	16.82	16.82	16.85	16.84	15.30	15.30	15.30	15.30
EE (%)	3.76	3.76	3.88	3.83	3.71	3.71	3.71	3.71
CF (%)	3.91	3.91	4.02	3.97	3.97	3.97	3.97	3.97
Ash (%)	3.95	3.95	4.02	4.00	3.70	3.70	3.70	3.70
Calcium (%)	0.83	0.80	0.75	0.75	1.03	1.01	0.97	0.99
Phosphor total (%)	0.42	0.42	0.43	0.42	0.38	0.39	0.38	0.38
Phosphor available (%)	0.37	0.37	0.37	0.37	0.35	0.35	0.35	0.35
Sodium (%)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Chloride (%)	0.28	0.28	0.28	0.28	0.23	0.23	0.23	0.23
dEB	200	200	200	200	200	200	200	200
Lysine SID pig (%)	1.100	1.100	1.100	1.100	0.940	0.940	0.940	0.940
Methionine SID pig (%)	0.440	0.443	0.443	0.443	0.376	0.376	0.376	0.376
Met+Cys, SID pig (%)	0.670	0.670	0.670	0.670	0.580	0.580	0.580	0.580
Threonine SID pig (%)	0.700	0.700	0.700	0.700	0.610	0.610	0.610	0.610
Tryptophan SID pig (%)	0.220	0.220	0.220	0.220	0.190	0.190	0.190	0.190
Valin SID pig (%)	0.890	0.890	0.890	0.890	0.640	0.640	0.640	0.640
Isoleucine SID pig (%)	0.600	0.600	0.600	0.600	0.520	0.520	0.520	0.520

Table 6. Pig feed formula for the period 70 kg - finish

Ingredient (%)	I	II	III	IV
Grain corn	57.62	57.51	57.36	57.38
Single-cell protein powder	3.00	3.00	3.00	3.00
Single-cell protein liquid	3.20	3.22	3.26	3.24
Cassava residue	15.00	15.00	15.00	15.00
Soybean meal 46	15.30	15.30	15.30	15.30
Soybean oil	0.28	0.28	0.29	0.29
Colistin 1%	-	0.05	-	-
BMD 10%	-	0.03	-	-
Phytogenics	-	-	0.04	0.04
Organic acid	-	-	0.10	0.10
Probiotics	-	-	0.05	-
Halor Tid	-	-	-	0.05
Other ingredients*	5.60	5.60	5.60	5.60
Total	100	100	100	100

** "Other ingredients" include acid amin, premix, salt, limestone, DCP, enzymes.*

Table 7. Nutrients of feed for the period 70 kg - finish

	I	II	III	IV
DM (%)	86.00	86.00	86.00	86.00
MEg (kcal/kg)	3,162.00	3,160.00	3,156.00	3,158.00
CP (%)	14.54	14.53	14.53	14.53
EE (%)	3.09	3.09	3.09	3.09
CF (%)	3.72	3.72	3.71	3.71
Ash (%)	4.31	4.31	4.30	4.30
Calcium (%)	1.20	1.20	1.20	1.20
Phosphor total (%)	0.40	0.40	0.40	0.40
Phosphor available (%)	0.32	0.32	0.32	0.32
Sodium (%)	0.35	0.35	0.35	0.35
Chloride (%)	0.52	0.52	0.52	0.52
dEB (%)	200.00	200.00	200.00	200.00
Lysine SID pig (%)	0.840	0.840	0.840	0.840
Methionine SID pig (%)	0.348	0.349	0.349	0.349
Met+Cys, SID pig (%)	0.530	0.530	0.530	0.530
Threonine SID pig (%)	0.560	0.560	0.560	0.560
Tryptophan SID pig (%)	0.170	0.170	0.170	0.170
Valin SID pig (%)	0.570	0.570	0.570	0.570
Isoleucine SID pig (%)	0.470	0.470	0.470	0.470

Live weight, feed consumption, number of diarrhea days and number of dead/culled of pigs were recorded at beginning and ending of each stage of the trial. The back-fat thickness of every pig was measured at three days before slaughtering by back-fat thickness measuring machine (trade name Renco). At the end of trial, one pig per treatment was slaughted to evaluate carcass on carcass weight percentage and carcass dressing percentage. Finally, make comparisons of economic efficiency of experimental treatment based on the cost of feed and veterinary medicine expense for one kg of pig live weight gained. The data were statistically analyzed by Minitab 17.0 using ANOVA, Tukey test and Chi square test for corresponding parameter. A significant difference was set at $P \leq 0.05$.

3. Results and Discussion

3.1. Growth performance

The average live weight of pigs in all four treatments at the beginning of the experiment was similar. Pigs raised at the 7 - 15 kg stage mostly gained relatively low weight, in which the highest weight was found in treatment II - 13.61 kg/pig, followed by treatment IV - 13.34 kg/pig. During this period, pigs experienced stress due to many factors such as changing the farming environment, joining new herds and changing feed, leading to severe diarrhea and poor feed consumption. Treatment II which supplemented antibiotics in diet reduced diarrhea challenges hence, leading to better growth. At the same time, treatment IV used anti-bacterial peptides combined with phytogenic and organic acids to show the best impact. Replacing antibiotics

with anti-bacterial peptides aimed at improving intestinal health should help pigs have higher weight compared to the other two treatments. The post-weaning period of pigs (7-15 kg) was an extremely sensitive period. Therefore, it is not only the diet be composed of nutrition and high digestible ingredients, but also have supplements that support intestinal health. It would help pigs reduce diarrhea, keep pigs healthy, and better feed intake to achieve high growth, as shown in the results in Table 8.

Table 8. Live weight (LW) (kg/pig ± SD) and average daily weight gain (ADG) (kg/pig per day ± SD) of experimental pigs through stages of feeding

Treatment	I	II	III	IV	*P*
LW 1st day	8.06 ± 1.12	8.02 ± 0.68	8.02 ± 0.54	8.03 ± 0.74	0.999
LW period 7 - 15 kg	13.02 ± 3.04	13.61 ± 5.58	13.10 ± 2.29	13.34 ± 1.37	0.931
LW period 15 - 25 kg	27.91 ± 7.25	30.01 ± 3.76	29.54 ± 3.17	30.47 ± 2.58	0.548
LW period 25 - 40 kg	46.42 ± 13.66	49.57 ± 4.95	48.18 ± 5.53	50.22 ± 4.46	0.670
LW period 40 - 70 kg	64.93 ± 19.96	70.12 ± 5.31	69.22 ± 6.59	70.32 ± 5.41	0.611
LW end day	89.30 ± 28.40	97.61 ± 6.17	96.94 ± 8.25	97.78 ± 6.4	0.478
ADG 7 - 15 kg	0.248 ± 0.16	0.279 ± 0.12	0.254 ± 0.11	0.266 ± 0.06	0.920
ADG 15 - 25 kg	0.647 ± 0.22	0.713 ± 0.07	0.715 ± 0.12	0.745 ± 0.06	0.358
ADG 25 - 40 kg	0.882 ± 0.32	0.931 ± 0.11	0.888 ± 0.15	0.941 ± 0.13	0.837
ADG 40 - 70 kg	0.882 ± 0.32	0.979 ± 0.10	1.002 ± 0.10	0.957 ± 0.08	0.391
ADG 70 kg - finish	1.059 ± 0.47	1.195 ± 0.15	1.205 ± 0.18	1.194 ± 0.13	0.500
ADG whole trial	0.752 ± 0.26	0.830 ± 0.06	0.823 ± 0.08	0.831 ± 0.06	0.467

After a first period, the pigs in treatment II, III and IV showed relatively better weight gain, they continued to grow rapidly and reached an average body weight at slaughter of approximately 97 kg after a 108-day feeding. They also had a pretty good average daily weight gain of about 0.830 kg/pig per day. In contrast pigs in treatment I, the negative control which did not receive means to support intestinal health, reached their final weight and average daily weight gain not good, only 89.30 kg/pig and 0.752 kg/pig per day, respectively.

3.2. Feed efficiency

Table 9. Feed intake and Feed conversion ratio of experimental pigs through stages of feeding

Treatment	I	II	III	IV	*P*
FI[1] 7 - 15 kg	0.403 ± 0.06	0.417 ± 0.04	0.401 ± 0.05	0.407 ± 0.02	0.938
FI 15 - 25 kg	1.213 ± 0.17	1.132 ± 0.10	1.071 ± 0.05	1.147 ± 0.05	0.246
FI 25 - 40 kg	1.797 ± 0.21	1.784 ± 0.15	1.625 ± 0.14	1.682 ± 0.24	0.352
FI 40 - 70 kg	2.561 ± 0.30	2.476 ± 0.14	2.424 ± 0.13	2.366 ± 0.19	0.781
FI 70 kg - finish	3.557 ± 0.43	3.673 ± 0.14	3.587 ± 0.28	3.533 ± 0.34	0.879
FI total trial	1.870 ± 0.13	1.929 ± 0.08	1.853 ± 0.12	1.859 ± 0.13	0.673
FCR[2] 7 - 15 kg	1.83 ± 0.68	1.51 ± 0.16	1.62 ± 0.21	1.55 ± 0.17	0.484
FCR 15 - 25 kg	1.69^{a} ± 0.13	1.59^{ab} ± 0.08	1.51^{b} ± 0.12	1.54^{ab} ± 0.07	0.029
FCR 25 - 40 kg	1.86 ± 0.15	1.92 ± 0.06	1.84 ± 0.09	1.79 ± 0.09	0.220
FCR 40 - 70 kg	2.52 ± 0.16	2.53 ± 0.08	2.43 ± 0.20	2.47 ± 0.18	0.662
FCR 70 kg - finish	3.17 ± 0.52	3.09 ± 0.28	2.98 ± 0.14	2.96 ± 0.13	0.637
FCR total trial	2.49 ± 0.48	2.33 ± 0.08	2.25 ± 0.11	2.24 ± 0.09	0.331

[1]"FI" feed intake (kg/pig per day ± SD), [2]FCR" feed conversion ratio (kg feed/kg gain ± SD). Means in the same row with different superscript letters are significantly different (P < 0.05).

Pigs in good health will eat much to get much more nutrients, to obtain added nutrients, resulting in a rapid increase in body mass. Looking at Table 9, treatment II which supplemented antibiotics in diet had a higher feed intake than treatment I which without added antibiotics; the figures were respectively 1.929 kg/pig per day and 1.870 kg/pig per day. Furthermore, pigs in treatment II had lower diarrhea and good growth, therefore it had a quite good feed conversion ratio (FCR) compared to the FCR of pigs in treatment I (2.33 and 2.49 kg of feed/kg of weight gain, respectively). Although, pigs in treatment III and IV were relatively lower than the diet of pigs in treatment II (1.853 kg/pig per day, 1.859 kg/pig per day and 1.929 kg/pig per day, respectively), but pigs in treatment III and IV still achieved good weight gain as shown in Table 8, leading to a FCR better than pigs in treatment II and of course even better than pigs in treatment I. The reason may be that pigs in treatment III and IV were fed feed which was combined tools to support intestinal health with natural products, while also having the ability to control harmful bacteria, thus minimizing diarrhea and enhance pig health, without causing adverse effects on beneficial bacteria in the pig's intestinal tract like using antibiotics in pig feed in treatment II.

3.3. Health status of experimental pigs

Table 10. Percentage of days of diarrhea in pigs

Stage	Treatment	I	II	III	IV	*P*
7 - 15 kg	Number of pig (pig)	12	12	12	12	
	Number of days of feeding (day)	240	240	240	240	
	Number of days of diarrhea (day)	211	196	217	203	
	Percentage of days of diarrhea (%)	87.92^{ab}	81.67^{b}	90.42^{a}	84.58^{ab}	0.046
15 - 25 kg	Number of pig (pig)	11	12	12	12	
	Number of days of feeding (day)	253	276	276	276	
	Number of days of diarrhea (day)	63	67	54	50	
	Percentage of days of diarrhea (%)	24.28	24.90	19.57	18.12	0.320
Total trial	Number of pig (pig)	12	12	12	12	
	Number of days of feeding (day)	1208	1296	1296	1296	
	Number of days of diarrhea (day)	333	295	310	281	
	Percentage of days of diarrhea (%)	27.57^{a}	22.76^{b}	23.92^{ab}	21.68^{b}	0.044

^{a,b}*Means in the same row with different superscript letters are significantly different (P < 0.05).*

Table 10 showed the percentage of days of diarhea in pigs. In first period of the experiment, pigs in all treatments had a very high rate of diarrhea, especially in treatment I which had not antibiotics or other supplements to protect intestinal health in feed, so pigs had prolonged diarrhea; despite being treated with the same medication as other pigs diarrhea, they still too weak and lost weight, leading to having one pig to be culled at the end of first feeding. Although treatment II used antibiotics to prevent diarrhea in second period, the diarrhea rate was still high and equivalent to treatment I; this may be due to the negative impact of antibiotics on the balance of intestinal microorganisms when used for a long time. In contrast, treatments III and IV after an initial feeding, there was also severe diarrhea, but perhaps the impact to the presence of supplements to protect intestinal health, in the next period it decreased. Treatment IV perhaps helps to use of the anti-bacterial peptides in the feed, it has the effect of inhibiting diarrhea-causing bacteria no less than the effect of antibiotics, without adverse impact on beneficial bacteria in the intestinal tract, so during the entire experimental period, pigs in treatment IV had the lowest rate of diarrhea per day (21.68%) compared to pigs in other treatments. This result is like the study of Duong et al. (2019) in reducing diarrhea in pigs when using products having peptides.

Table 11. Number of pigs alive (pig) and survival ratio (%) of experimental pigs

Period	Treatment I		Treatment II		Treatment III		Treatment IV	
	Number of pig	Survival ratio (%)	Number of pig	Survival ratio (%)	Number of pig	Survival ratio (%)	Number of pig	Survival ratio (%)
7 - 15 kg	12	100	12	100	12	100	12	100
15 - 25 kg	12	91.67	12	100	12	100	12	100
25 kg - finish	11	100	12	100	12	100	12	100
Total trial	12	91.67	12	100	12	100	12	100

Pigs in all three treatments II, III and IV had a survival rate up to 100%, except for treatment I which only reached 91.67% because one pig was eliminated when moving from stage 7 - 15 kg to stage 15 - 25 kg. The pig did not have typical disease symptoms, but it had diarrhea in the first stages, ate less and lost weight suddenly, with no ability to recover, so it must be culled. The detail of figures were presented in Table 11.

Table 12. Carcass traits of finished experimental pigs

Treatment	I	II	III	IV
Live weight (kg)	92.54	93.54	94.48	93.50
Weight of the dressed carcass (kg)	75.70	77.72	80.36	76.36
Percentage of the dressed carcass (%)	81.80	83.09	84.61	81.67
Weight of the carcass (kg)	68.58	66.42	72.64	68.26
Percentage of the carcass (%)	74.11	71.01	76.48	73.01
Back-fat thickness (n = 47), mm	13.33 ± 1.71	14.00 ± 1.39	13.42 ± 2.00	12.61 ± 1.01

At the end of experiment after 108 days of feeding, in each treatment, selected one pig of similar weight to slaughter and evaluate carcass traits. As for back-fat thickness of pigs, it was measured directly on all live pigs 3 days before finishing the experiment. The results in Table 12 did not show much difference between 4 treatments, although pigs in treatment II with feed supplemented of antibiotics had the lowest carcass rate and the highest back-fat thickness compared to pigs in the remaining three treatments, but because the number of slaughtered pigs is only one pig/treatment, it is not enough to analyze the statistical significance of this difference.

3.4. Economic efficiency

Table 13. Compare costs between experimental treatments

	Treatment I	Treatment II	Treatment III	Treatment IV
Feed consumed in stage 1 (kg)	97	100	96	97
Unit price of feed (vnd/kg)	14,162	14,266	14,398	14,516
Feed cost in stage 1 (vnd)	1,373,714	1,426,600	1,382,208	1,408,052
Feed consumed in stage 2 (kg)	299	312	296	316
Unit price of feed (vnd/kg)	11,606	11,715	11,866	11,981
Feed cost in stage 2 (vnd)	3,470,194	3,655,080	3,512,336	3,785,996
Feed consumed in stage 3 (kg)	408	450	410	424
Unit price of feed (vnd/kg)	10,397	10,506	10,659	10,774
Feed cost in stage 3 (vnd)	4,241,976	4,727,700	4,370,190	4,568,176
Feed consumed in stage 4 (kg)	559	624	611	596
Unit price of feed (vnd/kg)	9,825	9,934	9,984	9,995
Feed cost in stage 4 (vnd)	5,492,175	6,198,816	6,100,224	5,957,020
Feed consumed in stage 5 (kg)	890	1014	990	975
Unit price of feed (vnd/kg)	9,497	9,600	9,643	9,752
Feed cost in stage 5 (vnd)	8,452,330	9,734,400	9,546,570	9,508,200
Feed cost all total trial (vnd) (1)	23,030,389	25,742,596	24,911,528	25,227,444
Medicine cost (vnd) (2)	163,480	23,000	41,260	61,790
Total weight gain of experimental pigs (kg) (3)	975	1,075	1,067	1,077
(Feed cost + Medicine cost)/kg weight gain (vnd/kg) (1 + 2)/3	23,789	23,968	23,386	23,481
Compared to treatment I (vnd/kg)	-	+ 179	- 403	- 308
Difference from treatment I (%)	-	+ 0.75	- 1.69	- 1.29
Saved to treatment II (%)	-	-	- 1.68	- 1.28

Price of raw materials used to produce feed as of July 2023.

After 108 days of feeding trial, pigs in treatment I which was fed diet without any supplements to enhance of gut health status expressed worst performance on live weight, daily weight gain (ADG), FCR and especially on problem of diarrhea and survival ratio. Pigs fed diet with combination of phytogenic plus organic acid plus probiotics in treatment III gained body weight and FCR better than pigs which received diet supplemented with antibiotics (treatment II), although this difference is not statistically significant at $P > 0.05$. In another way, the feed cost per kg of live weight of pigs which was showed in Table 13 in treatment III and treatment IV was saved significantly compared to that of pigs in treatment II and of course much better than of pigs in treatment I.

4. Conclusions

From the above results, it shows that using anti-bacterial peptides combined with phytogenic and organic acid helps pigs reduce diarrhea and health, so they will achieve better growth and FCR than only using antibiotics alone, and thereby bring better economic efficiency to farmers.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

The authors would like to express our deep gratitude to Anh Duong Khang Ltd. Co. for supporting us with materials and conditions to achieve this study.

References

Duong, K. N., Do, D. T., Dang, A. T. N., Tran, A. T., Tran, K. T. M., Jarchow, A., & Wickern, A. Z. (2019). Investigation of bioactive peptides supplementation in diet for growth performance of weaning-finishing pigs in Vietnam. *Journal of Animal Husbandry Sciences and Technics (JAHST)* 24, 29-33.

Pearlin, B. V., Muthuvel, S., Govidasamy, P., Villavan, M., Alagawany, M., Farag, M. R., Dhama, K., & Gopi, M. (2020). Role of acidifiers in livestock nutrition and health: A review. *Journal of Animal Physiology and Animal Nutrition* 104(2), 558-569. https://doi.org/10.1111/jpn.13282.

Rahman, M. R. T., Fliss, I., & Biron, E. (2022). Insights in the development and uses of alternatives to antibiotic growth promoters in poultry and swine production. *Antibiotics* 11(6), 766. https://doi.org/10.3390/antibiotics11060766.

Silveira, R. F., Roque-Borda, C. A., & Vicente, E. F. (2021). Antimicrobial peptides as a feed additive alternative to animal production, food safety and public health implications: An overview. *Animal Nutrition* 7(3), 896-904. https://doi.org/10.1016/j.aninu.2021.01.004.

Wang, J. J., Dou, J. X., Song, J., Lyu, F. Y., Zhu, X., Xu, L., Li, Z. W., & Shan, S. A. (2019). Antimicrobial peptides: Promising alternatives in the post feeding antibiotic era. *Medicine Research Reviews* 39(3), 831–859. https://doi.org/10.1002/med.21542.

Xiao, H., Shao, Y. F., Wu, M. M., Ren, K. W., Xiong, X., Tan, B., & Yin, L. J. (2015). The application of antimicrobial peptides as growth and health promoters for swine. *Journal of Animal Science and Biotechnology* 6, 19. https://doi.org/10.1186/s40104-015-0018-z.

Xu, B. C., Fu, J., Zhu, L. Y., Li, Z., Wang, Y. Z., & Jin, M. L. (2020). Overall assessment of antimicrobial peptides in piglets: A set of meta-analyses. *Animal* 14(2), 2463-2471. https://doi.org/10.1017/s1751731120001640.