Effects of dietary supplementation of shrimp head and shell by-products on growth performance and incidence of diarhea in fattening pigs from 96 to 164 days of age

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ABSTRACT

The objective of this study was to evaluate effects of dietary supplementation of shrimp head and shell by-products on growth performance and incidence of diarhea in fattening pigs from August 2023 to October 2023 at the pig farm in Thoai Son district, An Giang province. A total of 90 crossbred pigs [(Duroc x Pietrain) x (Landrace x Yorkshire); 96 days old] were assigned to 1 of 3 treatments with 5 replicate pens of 6 pigs each according to sex, litter origin, and weight in a randomized complete block design (RCBD). The 3 dietary treatments included (1) Basal diet (control), (2) Basal diet + 3 g/kg shrimp hydrolysate powder (SH) and (3) Basal diet + 10 g/kg shrimp heads and shells meal (SM). The results showed that there were no significant differences in the average body weight (BW) and average daily gain (ADG) among the 3 treatments ($P > 0.05$). Similarly, pigs fed the SH diet (2.99) and SM diet had the same feed conversion ratio (FCR) of pigs ($P = 0.767$) as those fed the control diet (3.04) during the whole period from 96 to 164 days of age. Furthermore, no significant differences ($P > 0.05$) were found in the average daily feed intake (ADFI) and the diarrhea incidence among the 3 treatments. Briefly, the results in the current study suggest that dietary supplementation of shrimp head and shell by-products (shrimp hydrolysate powder, or shrimp heads and shell meal) seem to have no positive effects on growth productivity (BW, ADG, ADFI and FCR) and incidence of diarrhea in fattening pigs during 96 - 164 days of age.

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1. Introduction

Shrimp processing for export releases many by-products during the production process; waste from the shrimp processing industry mainly includes the head, chest, carapace, and tail, accounting for 50% of the whole shrimp (Thiago et al., 2012). Taking advantage of available by-products from the shrimp production industry to become a source of protein-rich feed ingredients is a direction in line with the circular farming trend that is being interested in the livestock farming practice to solve the problem of shortage of feed ingredients and reduce negative impacts on the ecosystem. Chitin is the primary component in shrimp shells, making up 15 - 40% of their composition (Abuzar et al., 2023). This substance can be extracted through a process known as the chitin recovery method, resulting in a product commonly used in livestock farming called chitosan; after hydrolyzing chitosan with enzymes (Pham et al., 2017) to create shrimp-derived oligosaccharide higher the biological value. Recently, it has been demonstrated that the feed conversion ratio (FCR) (Han et al., 2007) and the average daily gain (ADG) (Chatchai et al., 2019) of fattening pigs were significantly improved when they fed daily diets contained chitosan at 1 g/kg and 0.3 g/kg, respectively.

Furthermore, it has been reported that shrimp hydrolysate powder produced from shrimp heads and shells by the chemical hydrolysis method is being studied and proven to be effective in livestock farming (Liu et al., 2021; Ngo et al., 2021). Increasing the number of short-chain peptides in daily diets supported easier and better absorption in the digestive tract of livestock (Ngo et al., 2021); as well as the appearance of many amino acids that stimulate the appetite of livestock (taurine, glycine, alanine) (Liu et al., 2021). In Vietnam, however, the practical benefits of by-products from the shrimp industry in pig production are still limited in both academic research and feasible applications.

Therefore, the objective of the current study was to determine the effects of one product that contained by-products from shrimp (head and shells) on growth performance, feed consumption and diarrhea disease in pig production at the fattening stage.

2. Materials and Methods

2.1. Location

The study was conducted at the pig farm of Thoai Son district, An Giang province from August, 2023 to October, 2023.

2.2. Experimental design, animals and housing

A total of 90 crossbred pigs [(Duroc x Pietrain) x (Yorkshire - Landrace)] at 96 days of age with an initial average body weight (BW) of 43.67 1.1 kg were assigned to a randomized complete design with three dietary treatments (five replicate pens per treatment, three barrows and three gilts per pen). The average BW ($P > 0.05$), pigs' sex and litter were almost similar among the 3 treatments. Three dietary treatments consisted of (1) the basal diet (control), (2) basal diet supplemented with 3 g/kg shrimp hydrolysate powder (SH), and (3) basal diet supplemented with 10 g/kg shrimp head and shell meal (SM) (Both SH and SM provided by a commercial company) (Table 1).

Table 1. Experimental design

Treatment	Control	SH	SM
Pigs per pen, n	6	6	6
Replicate, pen	5	5	5
Total pigs	30	30	30
Duration, days	68	68	68
Pigs' dietary by-products shrimp addition, g/kg feed	0	3	10

SH: Shrimp hydrolysate powder; SM: Shrimp heads and shells meal.

Pigs were housed in an environmentally controlled building. Each pen measured 2 x 3 m in size with a slatted floor and had two nipple waterers. The chemical compositions of shrimp hydrolysate powder was shown in Table 2.

Table 2. Chemical and amino acid compositions of shrimp hydrolysate powder

Nutrients	Levels	Essential amino acids	Percentage (%)	Non-essential amino acids	Percentage (%)
Dry matter	86%	Arginine	1.22	Glutamic acid	2.33
Crude protein	30%	Histidine	0.56	Aspartic acid	1.47
Astaxanthin	11.45 ppm	Lysine	0.95	Glycine	1.43
		Leucine	1.43	Proline	1.01
		Methionine	0.46	Cystine	0.23
		Threonine	0.83	Valine	1.14
		Isoleucine	0.90		
		Phenyl alanine	1.04		

2.3. Experimental condition

2.3.1. Experimental diets and animal feeding

The daily mash feed as a basal diet was formulated with chemical compositions as nutrient requirements for the fattening pigs recommended by the NRC (2012) from common ingredients (Table 3) (produced by An Giang Agricultural Import-Export Joint Stock Company). Although the additional shrimp-derived protein was added to the basal diet, which was consistent with protein in the basal diet.

All pigs were fed twice a day (7:30 and 14:00, *ad libitum*) with distinguishing diets for each treatment. The experimental condition was set up in a temperature-controlled room and had free access to water and feed throughout the trial.

Table 3. Ingredients and chemical compositions of the basal diets

	Items	Percentage
Ingredients	Corn bran	35.58
	Rice bran	10
	Casava root meal	12
	Soybean waste	20
	Soybean meal	20
	Minerals	1.1
	Premix	1.1
Chemical compositions	ME, Kcal/kg	3,050
	CP, %	16.4
	Lysine, %	0.82
	Met + Cys, %	0.48
	Threonine, %	0.58
	Tryptophan, %	0.19

2.4. Sample collection and measurements

The BW and feed consumption were measured at the initial and final times of this experiment. Then, the ADG, average daily feed intake (ADFI), and FCR were calculated.

The incidence of diarrhea was recorded on a daily basis and based on fecal scores were based on 1 to 5 scale: 1 = normal; 2 = moist feces; 3 = mild diarrhea; 4 = severe diarrhea; 5 = watery diarrhea. The incidence of diarrhea was calculated by counting pig days with diarrhea score of 3 or greater during the whole experimental duration.

2.5. Statistical analysis

Data were analysed as a randomized complete block design by ANOVA using the GLM procedure (Minitab 16.2). The pen was considered the experimental unit. The incidence of diarrhea was compared by $\chi 2$ analysis. Treatment effects were considered significant at $P < 0.05$.

3. Results and Discussion

3.1. Growth performance

Table 4. Effect of dietary Shrimp hydrolysate powder (SH) and Shrimp heads and shells meal (SM) supplementation on body weight (kg/pig) of fattening pigs

Days of age	Treatments[1]			SEM	*P*
	Control	SH	SM		
96	42.41	44.41	44.20	0.095	0.602
135	69.93	71.75	72.94	0.131	0.695
164	91.84	96.95	95.28	0.225	0.494

[1]*5 pens/treatment and 6 pigs/pen.*

There were no significant differences in BW among the 3 treatments at 96 days of age (P = 0.602; Table 4). Similarly, dietary supplementation at 3 g/kg SH or 10 g/kg SM did not significantly increase (P = 0.695) the BW at 135 days of age (71.75 and 72.94 kg, respectively) compared with that of the control (69.93 kg/pig). The BW of the SH treatment was also similar (96.95 kg/pig) to those of the SM (95.28 kg/pig) and control treatments (91.84 kg) at the end of the experimental period (P = 0.494). Therefore, our current results indicated that dietary inclusion of SH at 3 g/kg or SM at 10 g/kg in the fattening period seems to have no positive impact on the BW of the fattening pigs. In contrast, Liu et al. (2021) demonstrated that shrimp heads are a source of unsaturated fatty acids, crude protein, essential amino acids, macro and micro minerals. It also reported that hydrolyzed shrimp protein contains many amino acids and di/tripeptides that help animals absorb directly, save energy for digestion, and at the same time stimulate appetite and bring a delicious feeling (Ngo et al., 2021).

There was no significant difference in the ADG among the 3 treatments in the period from 96 to 134 days of age (P = 0.792; Table 5), although pigs fed diets added the SH had numerically greater ADG (0.90 kg/day) than those of the SM (0.80 kg/day) and control treatments (0.78 kg/day) in the period of 135 - 164 days of age (P = 0.160). Besides, the ADG of pigs was not significantly different among the three treatments (control, SH, and SM treatments at 0.72, 0.77 and 0.75 kg/day, respectively) in the period of 96 - 164 days of age. Therefore, dietary supplementation of SH at 3 g/kg or SM at 10 g/kg has no positive impact on the ADG of the fattening pigs in the fattening period.

Table 5. Effect of dietary Shrimp hydrolysate powder (SH) and Shrimp heads and shells meal (SM) supplementation on average daily gain (kg/day) of fattening pigs

The period (days of age)	Treatments[1]			SEM	*P*
	Control	SH	SM		
96 - 134	0.68	0.68	0.72	0.002	0.792
135 - 164	0.78	0.90	0.80	0.006	0.160
96 - 164	0.72	0.77	0.75	0.002	0.606

[1]*5pens/treatment and 6 pigs/pen.*

3.2. Average daily feed intake (ADFI)

There were no significant differences (P > 0.05; Figure 1) in the ADFI among the 3 treatments in the period from 96 to 134 days of age (control, SH or SM at 1.87, 1.92 or 1.89 kg/day, respectively) and from 135 to 164 days of age (control, SH and SM at 2.70, 2.79 or 2.70 kg/day, respectively). Besides, during the whole experimental period, pigs fed diets supplemented the SH or the SM did not significantly increase the ADFI (2.30 or 2.24 kg/day, respectively) (P = 0.157) compared with that of the control (2.19 kg/day). Therefore, dietary supplementation of SH at 3 g/kg or SM at 10 g/kg has no beneficial effect on the ADFI in the fattening period period. On the contrary, previous studies indicated that shrimp heads contain about ten types of distinguishing proteases, including myofibril-associated serine proteinase, chymotrypsin, cathepsin B, pepsin, serine protease, trypsin, metalloprotease, cathepsin L, collagenase, and calpain (Xu et al., 2012) and contain many amino acids that stimulate the appetite of pigs, especially accounted for 10% glutamic acid (Liu et al., 2021), leading to increase the average daily feed intake of pig fed dietary SH supplementation (Xu et al., 2012; Liu et al., 2021).

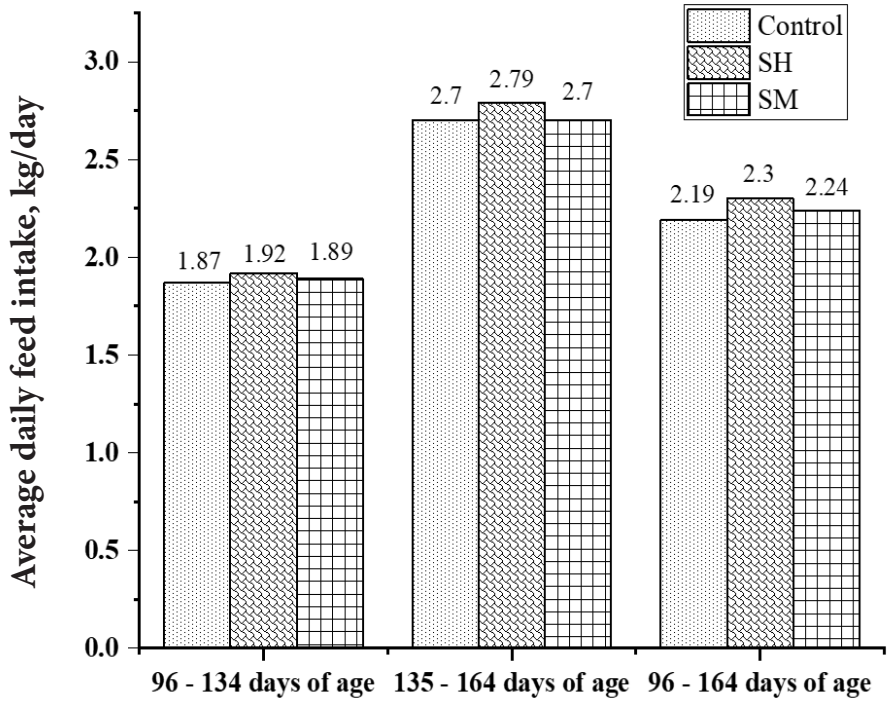

Figure 1. Effect of dietary Shrimp hydrolysate powder (SH) and Shrimp heads and shells meal (SM) supplementation on average daily feed intake of fattening pigs (kg/day).

3.3. Feed conversion ratio (FCR)

The FCR of pigs in the control treatment (2.77) in the period from 96 to 134 days of age was significantly higher than that of the SM treatment (2.63) ($P < 0.01$; Table 6). In addition, the control treatment witnessed an upward trend on the FCR (3.45) and significantly higher than that of the SH treatments (3.05) ($P < 0.01$) in the period of 135 - 164 days of age. It has been indicated that shrimp hydrolysate powder contains several amino acids such as glutamic acid, alanine, arginine and glycine, known as feed palatability (Tantikitti, 2014), stimulating appetite and feed efficiency (Martinez-Alvarez et al., 2015). However, the FCR of pigs in the whole period from 96 to 164 days of age was not improved by the inclusion of the SM or SM (2.99) into the daily diet as compared with that of the control (3.04) ($P = 0.767$).

Table 6. Effect of dietary Shrimp hydrolysate powder (SH) or Shrimp heads and shells meal (SM) supplementation on the feed conversion ratio of fattening pigs

The period (days of age)	Treatments[1]			SEM	*P*
	Control	SH	SM		
96 - 134	2.77[a]	2.84[a]	2.63[b]	0.027	0.001
135 - 164	3.45[a]	3.05[b]	3.38[a]	0.052	0.001
96 - 164	3.04	2.99	2.99	0.051	0.767

[1]*5pens/treatment and 6 pigs/pen.*

[a-b]Within a row, means with different letters differ significantly (P < 0.05).

3.4. Diarrhea incidence

Table 7. Effect of dietary Shrimp hydrolysate powder (SH) and Shrimp heads and shells meal (SM) supplementation on feed conversion ratio (FCR) supplementation on the incidence of diarrhea during the experimental period

Parameter	Control	SH	SM	*P*
Diarrhea incidence[1], %	3.15	2.14	2.58	0.446

[1]Diarrhea incidence: Diarrhea x 100/pig days; Diarrhea: number of pig days with diarrhea; Pig days: number of pigs x the number of days of diarrhea observation.

In the period of 96 - 164 days of age, the incidence of diarrhea disease of control treatment was 3.15% and not different from those of the SM and SH treatments (2.14% and 2.58%, respectively) ($P > 0.05$, Table 7). The results in the current study showed that by-products shrimp supplementation into the daily diets for fattening pigs does not affect the diarrhea incidence. In contrast, the hydrolysis reaction of protein from shrimp heads creates bioactive peptides, which perform biological functions in the animal body (Duong et al., 2018). These peptides enhance the activity of the immune system, as recorded in experimental pigs fed dietary SH supplementation (Yin et al., 2008), thereby improving health status and reducing diarrhea in pigs (Yang et al., 2012; Chatchai et al., 2019).

4. Conclusions

The dietary supplementation of shrimp head or shell by-products (shrimp hydrolysate powder, or shrimp heads and shell meal) had no significant improvements in growth performance (BW, ADG, ADFI and FCR) and incidence of diarrhea in the fattening pigs from 96 to 164 days of age.

Conflict of interest

The authors have no conflicts of interest to declare.

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