PJN
ISSN 1680-5194

# PAKISTAN JOURNAL OF NUTRITION

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Pakistan Journal of Nutrition 7 (6): 806-810, 2008
ISSN 1680-5194
Asian Network for Scientific Information, 2008

# Effect of Substituting Shrimp Waste Hydrolysate of *Penaeus merguensis* for Fish Meal in Broiler Performance

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**Abstract:** The objective of this study is to measure the effect of substituting different levels of shrimp waste hydrolysate (SWH) from *Penaeus merguensis* for fish meal (FM) in broiler diet. The broilers were randomly assigned in 4 different levels of SWH (0, 4, 8, and 12%) in experimental diet with a Completely Randomized Design. Each dietary treatment was replicated five times. The result of this experiment indicated that weight gain, feed conversion, and percentage nitrogen retention were affected significantly ($P<0.05$), and no significant differences were found for feed consumption, percentage carcass, percentage abdomen fat, and digestive organ size (liver, proventriculus, gizzard, cecum, and pancreas). The inclusion of SWH until 8% in broiler diet kept the weight gain and feed conversion stable as well as FM in diet, however the inclusion to 12% decreased weight gain and negative effect in feed conversion. In conclusion, SWH could be included to 8% in broiler's diet or substitute FM as alternative of animal protein source as much as 40%.

**Key words:** Shrimp waste hydrolysates, fish meal, broiler performance

## Introduction

Indonesia is one of the bigger shrimp exporter country after China in the world (Josupeit, 2004). According to Indonesia Bureau Central Statistic (2004) in 1996 and 2000 the shrimp was exported from Indonesia 162,22, and 220,520 tones respectively. In West Sumatera Province, (one of province of Republic of Indonesia) *Penaeus merguensis* is a major strain shrimp caught from the sea and in 2002 it was produced 4, 960 ton (West Sumatera Fishery Statistic, 2003). Generally, shrimp is exported from Indonesia in frozen shrimp without exoskeleton, or it sell at local market either with or without exoskeleton. The exoskeleton from shrimp frozen industry is abundance as shrimp waste and it is dumped and produced unpleasant smell in environment. The high protein content in shrimp waste is potentially as protein sources for substituting expensive fish meal in broiler diet. Some researchers found variation level of protein in shrimp waste, the level started from 39, 45 to 52, 70% (Mirzah, 1990; Gernat, 2001; Fanimo *et al*., 2004; Okoye *et al*., 2005). Mahata (2007) found the protein contain of shrimp waste from *Penaeus merguensis* is 24.03% in dry weight basis. The shrimp waste is also well-known has high calcium contain (Gernat, 2001; Fanimo *et al*., 2004 and Okoye *et al*., 2005). Unfortunately, the shrimp waste protein digestibility is low and absorption in small amount by broiler because of chitin compound. The amount of shrimp waste inclusion broiler diet is controversial Waskito *et al*. (1975) Romziah *et al*. (1981) Islam *et al*. (1994) and Arellano *et al*. (1997) measured 5-10, 15, 14, 25, and 9% respectively. Chitin is a linear polymer of *N*-acetyl-$_D$-glycocyamine unit linked ß (1, 4) glycosidic bonds (Minoru *et al*., 2002) and chitinase is enzyme that catalyze the hydrolysis of chitin to its simple monomer of *N*-acetyl-$_D$-glycocyamine (Park *et al*., 1997). Chitin physically blocks the access of digestive enzyme to protein and lipid, thus affecting the utilization of these nutrient (Castro *et al*., 1989). In alimentary digestive tract of broiler is not produce enough chitinase (E.C 3.2.1.14) to catalyze chitin hydrolysis (Jeuniaux and Cornelius, 1978). Thus chitin decomposition is needed for optimum utilization of shrimp waste as animal protein source in broiler diet. Some methods for chitin degradation in shrimp waste such as physical, chemical, biological and fermentation process have been carried out for repairing its nutrient quality (Mirzah, 1997; Filawati, 2003; Nwanna, 2003 and Syahrani, 2004). Hydrolyzing chitin in shrimp waste by using crude chitinase extracellular from *Serratia marcescens* (shrimp waste hydrolysate) could decreased chitin content by 61.07% and increased the protein content by 26.09% (Mahata *et al*., 2006). To date, very little data published concerning the use of shrimp waste hydrolysate in broiler diet. The objective of this study is to measure the effect of substituting different levels of shrimp waste hydrolysate (SWH) from *Penaeus merguensis* shrimp for fish meal (FM) in broiler diet.

## Materials and Methods

**Preparing shrimp waste hydrolysates and nutrient analysis:** Shrimp waste from *Penaeus merguensis* was

taken at local market in Padang city, West Sumatera Province, Indonesia. It was dried under the sun light for some days and then milled in 1.5 mm particle size. Crude chitinase production was performed by cultured *Serratia marcescens* bacterium in 0.5% liquid colloidal chitin medium (colloidal chitin wet 0.5%, yeast extract 0.05%, polypeptone 0.05%, $K_2HPO_4$ 0.14%, $KH_2PO_4$ 0.06%, $MgSO_4$ $7H_2O$ 0.25%) in pH 5.2 for 4 days. Crude chitinase was separated from bacteria by centrifuged at 8500 rpm for 15 minutes. The shrimp waste meal hydrolyzing process was performed in accordance to Mahata (2007) by using 4 unit crude chitinase and incubated with enzyme among 24 h. Activity of chitinase for hydrolyzing of shrimp waste was stopped by submerged the enzyme-substrate in boiling water ($100^{O}C$) for 5 minutes. After that, the shrimp waste was dried again under the sun light for some days. Prior to diet formulation. A proximate analysis were conducted on shrimp waste hydrolysates (SWH) in accordance to the Association of Official Analytical Chemist (AOAC, 1990). Metabolizable Energy (ME) value of SWH was calculated by Scaible method (1980) and chitin contain by Hong *et al.* (1989) (Table 1).

**Experimental diets and composition:** Four isocaloric and isonitrogenous were formulated in experimental diet. The SWH was included at 0, 4, 8, and 12% for diets A, B, C, and D respectively. Yellow corn was the major energy source while soybean meal and copra meal were used to adjust for both protein and energy diet (Table 3).

**Experimental animals and their management:** A total of eighty unsexed one week-old Arbor acres CP 707 breed broiler chicken purchased from local poultry shop at Padang city were individually weighed and than randomly allotted to four treatment diets. There were 20 birds per treatment and 4 birds per replicate in a completely randomized design. The broiler were environmental conditions. Feed and water were supplied *ad libitum*. Routine management practices were maintained.

**Data collection:** Broiler performance data for feed consumption, weight gain and feed conversion were collected for 6 weeks experimental period on weekly basis, while for nitrogen retention, percentage carcass, fat abdomen and digestive organs size were taken at the end of experimental period. Feed conversion was calculated by dividing the feed intake by the weight gain. Percentage carcass was calculated by dividing the carcass weight by body weight and multiple with 100%. Nitrogen retention is calculated by Sibbald (1975). Percentage abdomen fat was taken by weighed broiler abdomen fat and dividing with body weight and multiple with 100%. Digestive organ size (liver, proventriculus, gizzard, cecum and pancreas) are weighed, comparing with body weight and multiple by 100%.

Table 1: Proximate analysis of shrimp waste and shrimp waste hydrolysate (SWH) (as fed basis),chitin contain and metabolizable energy (ME) (kkal/kg)

| Components | Shrimp waste | Shrimp waste hydrolysates (SWH) |
|---|---|---|
| Water (%) | 7.87 | 4.10 |
| Dry matter (%) | 92.13 | 95.90 |
| Crude fiber (%) | 26.89 | 20.35 |
| Crude protein (%) | 24.03 | 30.30 |
| Fat (%) | 5.14 | 6.41 |
| Ash (%) | 25.60 | 26.31 |
| Calcium (%) | 16.69 | 16.35 |
| Phosphorus (%) | 0.85 | 0.83 |
| Nitrogen-free extractives (%) | 10.47 | 12.53 |
| Metabolizable Energy (kkal/kg)[1] | 938 | 2420 |
| Chitin (%) | 18.70 | 7.28 |

[1]Calculated by Schaibel method (1980) = 70% x Gross energy of SWH.

Table 2: Amino acid composition of shrimp waste hydrolysate(SWH) comparing with amino acid from fish meal

| Amino acid | Shrimp waste from hydrolysate *Penaeus merguensis* waste (%) (Mahata, 2007) | Fish meal (%) (Famino *et al.*, 1996) |
|---|---|---|
| Aspartic acid | 1.182 | 5.19 |
| Glutamic acid | 2.617 | 7.75 |
| Serine | 0.593 | 2.40 |
| Glycine | 0.876 | 5.38 |
| **Histidine** | 0.912 | 1.55 |
| **Arginine** | 0.597 | 3.61 |
| **Threonine** | 0.610 | 2.38 |
| Alanine | 0.715 | 4.14 |
| Proline | 0.485 | 3.27 |
| **Tyrosine** | 0.962 | 1.66 |
| **Valine** | 0.987 | 3.00 |
| **Methionine** | 0.508 | 1.09 |
| Cysteine | 0.878 | 0.90 |
| **Isoleucine** | 0.617 | 2.10 |
| **Leucine** | 0.685 | 4.14 |
| **Phenylalanine** | 0.711 | 2.24 |
| **Lysine** | 0.690 | 4.14 |
| Tryptophan | 0.063 | 0.56 |

Bold = Essential amino acid

**Statistical analysis:** A completely randomized design was adopted to execute this experiment and means showing significant differences in the ANOVA table were compared using the Duncan's Multiple Range Test (Steel and Torrie, 1980).

## Results

**The effect of SWH on feed consumption, weight gain, feed conversion, percentage carcass, percentage abdomen fat and nitrogen retention:** Statistical analysis showed significant difference ($P<0.05$) in the effects of SWH toward weight gain, feed conversion and nitrogen

Table 3: Composition of the experimental broiler diet (as fed basis)

| Feedstuffs (%) | A | B | C | D |
|---|---|---|---|---|
| Yellow corn | 45 | 45 | 45 | 45 |
| Rice bran | 21 | 15 | 10.5 | 25 |
| Soybean meal | 8 | 10 | 13 | 16 |
| Fish meal (FM) | 20 | 16 | 12 | 8 |
| Shrimp waste hydrolysate (SWH) | 0 | 4 | 8 | 12 |
| Copra meal | 3 | 7 | 8.5 | 75 |
| Coconut oil | 3 | 3 | 3 | 3 |
| Total | 100 | 100 | 100 | 100 |
| Calculated analysis: | | | | |
| Crude protein (%) | 22.69 | 22.42 | 22.2 | 22.20 |
| Metabolizable Energy (kcal/kg) | 2912.92 | 2914.48 | 2918.79 | 2924.10 |
| Fat (%) | 7.85 | 7.53 | 7.23 | 6.90 |
| Crude fiber (%) | 3.70 | 4.19 | 4.74 | 5.26 |
| Calcium (%) | 1.36 | 1.78 | 2.21 | 2.64 |
| Phosphorous (%) | 0.64 | 0.57 | 0.49 | 0.41 |
| Chitin %[1] | 0 | 0.29 | 0.58 | 0.85 |

[1]Calculated by multiple of SWH amount in experiment died with chitin contain in SWH.

Table 4: Performance of broiler chicken fed varying levels of shrimp waste hydrolysate (SWH)

| | Diets | | | |
|---|---|---|---|---|
| Parameters | SWH 0% | SWH 4% | SWH 8% | SWH12% |
| Feed consumption | 485.11 | 503.53 | 494.61 | 496.68 |
| Weight gain | 241.28[a] | 248.53 | 239.56[a] | 188.53[b] |
| Feed conversion | 2.02[a] | 2.03[a] | 2.06[a] | 2.50[b] |
| Percentage carcass | 63.51 | 62.60 | 65.58 | 60.97 |
| Percentage abdomen fat | 0.50 | 0.58 | 0.56 | 0.61 |
| Nitrogen retention | 64.81[a] | 64.33[a] | 64.33[a] | 59.81[b] |

Means that are not followed by the same letters are significantly different at $p<0.05$.

Table 5: The effect of SWH to digestive organelle percentage (liver, proventriculus, gizzard, cecum, and pancreas)

| Parameter | SWH 0% | SWH 4% | SWH 8% | SWH12% |
|---|---|---|---|---|
| Proventriculus | 0.54 | 0.53 | 0.54 | 0.62 |
| Gizzard | 2.47 | 2.11 | 2.58 | 2.16 |
| Cecum | 1.09 | 1.08 | 1.30 | 0.99 |
| Pancreas | 0.30 | 0.32 | 0.27 | 0.28 |
| Liver | 2.55 | 1.91 | 2.25 | 2.13 |

retention, while SWH is not affect feed consumption, percentage carcass and percentage abdomen fat. The data are shown in Table 4.

**The effect of SWH on digestive organs:** The average percentage of digestive organs: liver, proventriculus, gizzard, cecum and pancreas were not affected by shrimp waste (Table 5).

## Discussion

Table 4 revealed 12 SWH in experimental diet decreased weight gain and nitrogen retention, but it increased feed conversion and no significant effect in feed consumption, percentage carcass and percentage abdomen fat. Apparently, the inclusion of 12% SWH in diet is not decrease the diet palatability because the colour and flavor of diet are not

significantly different with control diet (diet with 0% SWH). Scott *et al.* (1982) stated colour and flavor diet are factors affecting broiler feed consumption, the bright colour more palatable than dark colour. Although broiler taste buts organ is not well develop, this factor is affected diet palatability. In this experiment, we suspected that high level of Ca and P with in balance ratio at 12 SWH (Table 3) due to the decreasing of weight gain and worse feed conversion. High level of Ca in SWH (Table 1) affect of Ca level in diet. Ideal ratio of Ca and P for poultry is 2:1 (NRC, 1984) and the ratio of Ca: P at 12% of SWH in diet in this experiment is 6.43: 1. Bronner (1987) stated that the circumstance of

the poultry intestine is almost acidic than alkaline and Kheiri and Rahmani (2006) found that Ca might increase the intestinal pH and consequently affect the digestion and absorption of nutrient. In this case, high levels of Ca in 12% SWH in diet increased and changed the intestinal pH of broiler from acidic to alkaline, this is a possible cause of lower protein digestion and absorption. Beside that, the nitrogen retention in this treatment is lower than the other (Table 4), its mean protein quality is poor because the inclusion of 12 SWH decreased the fish meal in broiler diet, while as shown in Table 2 the quality of amino acid in SWH is lower than fish meal, as well known the amino acid as protein component play an important role for broiler grower, thus weight gain and feed conversion are lower and worse in this treatment. This finding agree with Scott *et al*. (1982) which stated that protein plays an important role for broiler growing and protein deficiency will decrease weight gain. The interesting point in this experiment is the SWH was not affect the feed consumption up 12% in diet, but the weight gain and feed conversion in this treatment were lower than the other. This phenomenon indicated that protein and energy are not enough for broiler requirement regarding with lower protein digestion and quality, thus broiler arranged their consumption for protein and energy fulfil. Percentage carcass was not influenced by SWH in all levels in diet, due of this the percentage abdomen fat deposition and all organelles digestive (proventriculus gizzard, cecum, pancreas and liver) also was not affected by SWH (Table 5). And after reducing it from body weight the percentage carcass of broiler is not different for each treatment. We found in this experiment SWH could included up to 8% in broiler diet, this finding is higher than Raab *et al*. (1971) which was found the shrimp waste could incorporated into broiler diets at levels of 6.8%, but it lower than Mirzah (1997) which treated shrimp waste with high steam pressure and could be included 18% in broiler diet. Our finding also lower than Ilian *et al*. (1985) and Okoye *et* al. (2005) that found 10% shrimp waste could be included in broiler diet. The lower energy, high Ca and shrimp species are probably due the factor of the differences of our finding with the other report. To maximum utilization effort of SWH in broiler diet we should do Ca demineralization process in next experiment.

**Conclusion:** SWH could be included to 8% in broiler's diet or substitute FM as alternative of animal protein source as much as 40%.

## Acknowledgment

This experiment was funded by Department of National Education Republic of Indonesia. The authors are very grateful to Prof. Makoto Kawamukai at Biochemistry and Biotechnology Laboratory, Faculty of Life and Environmental Science, Shimane University, Japan who has taught for studying about chitinase and chitosanase enzyme.

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