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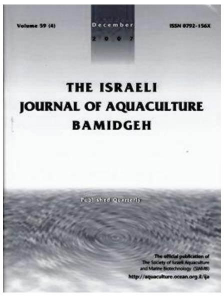

Effects of Partial Replacement of Fish Meal by Fermented Copra Meal on the Growth and Feed Efficiency in Black Tiger Shrimp, *Penaeus monodon*

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Key words: crustacean, aqua feeds, alternative protein source, growth, feed performance, protein efficiency ratio

Abstract

The potential of fermented copra meal (FCM) as an alternative to fish meal as a protein source for tiger shrimp, *Penaeus monodon* practical diet was evaluated. Five isonitrogenous (41% crude protein) diets with 0, 10, 20, 30 and 40% fish meal protein replaced with protein from FCM were formulated. *P. monodon* (average weight 0.38 ± 0.02 g) were distributed in 100 L capacity fiberglass tanks at 20 shrimp each. The diets were fed 4 times daily for 9 weeks initially at 15% of the shrimp ABW and reduced to 8%. The experiment was conducted in triplicate in a flow-through culture system. The parameters examined include growth, feed conversion ratio (FCR), survival, whole body nutrient composition, protein efficiency ratio (PER), and protein productive value (PPV) as a measure of protein retention. After the feeding trial, results demonstrated that regardless of the FCM replacement level in the diet, no significant differences were observed in all the parameters (growth, FCR, survival, whole body nutrient composition, PER and PPV) measured. Thus, fermented copra meal can be used as alternative protein source and can replace up to 40% of the fish meal protein in black tiger shrimp practical diet.

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Introduction

Fish meal (FM) is the major source of protein in aquafeed formulation. In shrimp in particular, it is usually included at 200 to 300 g/kg diet (Tacon and Akiyama, 1997). However, sources of fish meal are becoming scarce and its production is becoming unstable, resulting in increasingly higher prices. Reducing the inclusion of expensive ingredients particularly fish meal in feed is one way of lowering shrimp production costs. Therefore fish meal is being replaced in commercial feed to develop cost-effective diets and at the same time reduce fish meal utilization in aquaculture. Aquaculture utilizes an increasing share of the global fish meal production, from 2% in 1960, 10% in 1980 to 73% in 2010 (World Bank, 2013). In shrimp culture, an estimated 3.75 kg of fish are needed to produce 1 kg of shrimp (FCR=1.5, 5 kg fish for 1 kg fish meal, 250 g/kg fish meal inclusion rate) (Fox et al., 2004). The identification of alternative protein sources to replace fish meal is globally recognized as a research priority (Smith, 2000). Replacement of fish meal with plant meals at various levels has been studied in shrimp (Piedad-Pascual et al., 1990; Eusebio, 1991; Peñaflorida, 1995; Lim, 1996; Eusebio and Coloso, 1998; Sudaryono et al., 1999; Cruz-Suarez et al., 2001; Suarez et al., 2009; Kiron et al., 2012).

Copra meal (CM), the by-product of oil extraction from fruit/nuts of coconut, *Cocos nucifera* contains lower levels of anti-nutritional factors than legumes but its use as a dietary ingredient in monogastric animals is limited because of its high fiber content, gritty appearance, and coarse texture (Knudsen, 1997). On the other hand, biotreatment of copra by fermentation can reduce its fiber content, improve protein and essential amino acid composition, and enhance the color and odor of the meal.

Hence, this study was carried out to evaluate the effects of replacing fish meal with fermented copra meal protein in shrimp diet. The effects of the experimental dietary treatments on growth, survival, feed conversion ratio, protein efficiency ratio, and protein productive value were determined.

Materials and Methods

Test ingredient and feed formulation. The fermented copra meal (FCM) used in this study was purchased from a local feed company (Oversea Feeds Corporation, Cebu, Philippines). Five isonitrogenous diets (41% crude protein) were prepared with FCM progressively replacing fish meal protein at 0, 10, 20, 30, and 40% of the diet. Feed samples were analyzed for their proximate composition before the start of the feeding trial.

Experimental shrimp. Hatchery reared *P. monodon* were acclimatized to laboratory conditions and were fed the standard commercial shrimp diet for 1 week before the start of the feeding trial. Shrimp (average weight 0.38 ± 0.02g) were then stocked in 100 L capacity fiberglass tanks in a flow-through culture system with continuous aeration. Fifteen experimental tanks were randomly assigned for each dietary treatment with 3 replicates per diet. Shrimp samples were collected before the start of the feeding experiment for the determination of proximate composition.

Chemical analyses. Feed and shrimp samples were submitted for proximate analysis. Analyses for proximate composition of the samples were performed according to the methods of AOAC (1995).

Growth trials. The 9 week feeding trial was conducted using 100 L capacity fiberglass tanks. The shrimp were fed at 15% of their total biomass. This was later reduced to 8% of their total biomass. The daily feed ration was divided into 4 equal parts for the 8:00am, 11:00am, 2:00pm, and 5:00pm feeding schedule. Sampling for growth was done every 3 weeks by individually weighing all the shrimp in each tank. Feeding rates were adjusted after every sampling. When dead shrimp were collected, the feed ration was adjusted accordingly. The numbers of shrimp per tank were counted and survival calculated at the end of the 9 week feeding trial. Water quality was monitored regularly with average values as follows: temperature, 29.6ºC; salinity, 20 ppt; dissolved oxygen (DO), 5.88; pH, 8.03; ammonia, 0.15 mg/L; nitrite, 0.12 mg/L; and alkalinity, 132.9 (mg/li $CaC0_3$).

Statistical analysis. Data were analyzed statistically by one-way ANOVA using SYSTAT, SPSS software. Differences between dietary treatments were compared using Tukey's test. Values on survival were square root transformed and checked for normality before the statistical analysis was carried out. Results were considered statistically significant at $P \leq 0.05$.

Results

Experimental diets. The proximate composition of the locally purchased fermented copra meal (FCM) with 38% crude protein is presented in Table 1. The composition of the experimental diets is presented in Table 2. Crude protein content of the diets was similar while crude fat decreased as dietary FCM level was increased.

Table 1. Proximate composition of the fermented copra meal (FCM used in the formulation[1]

Parameters	*Analyzed values(%)*
Moisture	11.48
Crude protein	38.27
Crude fat	6.84
Crude fiber	6.44
Ash	9.61
Nitrogen free extract	38.83

[1] Dry matter basis.

Table 2. Formulation (g/kg) and proximate composition (%)[1] of the experimental diets

Ingredients (g/kg)	*Diet 1* *0%*	*Diet 2* *10%*	*Diet 3* *20%*	*Diet 4* *30%*	*Diet 5* *40%*
Basal Diet [2]	620	620	620	620	620
Fish Meal (Danish)	270	243	216	189	162
Fermented Copra Meal (FCM)	0	53.29	106.58	159.87	213.16
Rice Bran	110	83.71	57.42	31.13	4.84
Dry matter	93.98	93.37	94.26	94.16	94.68
Crude protein	42.01	41.49	41.34	41.43	41.02
Crude fat	9.56	8.45	8.37	7.22	7.27
Crude fiber	2.80	4.79	6.14	8.02	9.62
Ash	14.43	14.48	14.35	14.16	13.91
Nitrogen free extract	25.18	24.16	24.06	23.33	22.86

[1] Dry matter basis.
[2] Soybean meal 230g, *Acetes* sp. 115, Bread flour 150, Seaweed (*Gracilaria* sp.) 25, Cod liver oil 25, Soybean oil 25, Vitamin mix (V-22) 20, Mineral Mix 10, Dicalcium phosphate 20.

Growth and feed performance. Weight gain of *P. monodon* fed diets partially replaced with FCM at any replacement level was similar to the control group (Fig. 1). Replacement of fish meal by FCM protein to as much as 40% did not negatively affect the growth of the shrimp. Feed performance as indicated by feed conversion ratio (FCR) and survival were not affected by the inclusion of FCM in the shrimp diet (Table 3). FCR was similar for all dietary groups. Protein efficiency ratio (PER) was not influenced by FCM regardless of its level in the diet (Table 4). FCM has no adverse effect on the protein productive values (PPV), an indicator of protein retention (Table 4). Further, FCM inclusion at any dietary level did not significantly influence shrimp body nutrient composition (Table 5).

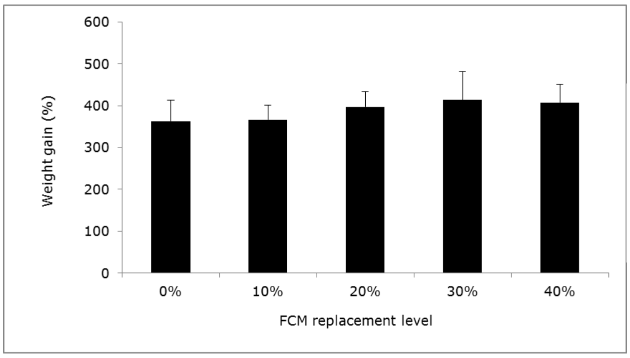

Fig. 1. Weight gain of *P. monodon* fed the experimental diets for 9 weeks. Means ± SE (n=3 tanks) are not significantly different (P>0.05).

Table 3. Growth, feed performance, and survival of *P. monodon* for 9 weeks*

Treatment	*Initial wt. (g)*	*Final wt. (g)*	*SGR (%/day)[a]*	*FCR[b]*	*Survival (%)*
Diet 1 (0%)	0.38	1.76 ± 0.38	7.24 ± 0.48	1.82 ± 0.70	28 ± 3.54
Diet 2 (10%)	0.38	1.77 ± 0.06	7.33 ± 0.15	1.81 ± 0.35	30 ± 5.41
Diet 3 (20%)	0.38	1.89 ± 0.02	7.73 ± 0.05	1.74 ± 0.48	30 ± 5.00
Diet 4 (30%)	0.38	1.95 ± 0.26	7.76 ± 0.62	1.73 ± 0.35	23 ± 2.89
Diet 5 (40%)	0.38	1.93 ± 0.16	7.70 ± 0.40	1.74 ± 0.20	30 ± 5.00

[*] Means ± SE (n=3) within a column are not significantly different (P>0.05).
[a] Specific Growth Rate = ((ln Final weight – ln Initial weight)/No. of days) x 100
[b] Feed Conversion Ratio = Feed consumed (g)/Weight gain (g)

Table 4. Protein efficiency ratio, protein productive value in *P.monodon* for 9 weeks*

Treatment	*Replacement Level (%)*	*PER[a]*	*PPV[b]*
Diet 1	0	1.26 ± 0.49	56.17 ± 2.07
Diet 2	10	1.29 ± 0.27	56.04 ± 2.25
Diet 3	20	1.25 ± 0.29	56.29 ± 0.73
Diet 4	30	1.28 ± 0.27	55.78 ± 1.04
Diet 5	40	1.30 ± 0.16	56.70 ± 1.53

[*]Means ± SE (n=3) within a column are not significantly different (P>0.05).
[a] Protein Efficiency Ratio = Weight gain (g)/Protein intake (g)
[b] Protein Productive Value

$$= \frac{[(\text{Final body protein, \%}) \times (\text{Final wt., g}) - (\text{Initial body protein, \%}) \times (\text{Initial wt., g})]}{\text{Wt. gain (g)} \times \text{Total protein intake (g)}} \times 100$$

Table 5. Proximate composition (%) of the shrimp carcass fed the experimental diets for 9 weeks*

Parameters	*Initial*	*Diet 1 0%*	*Diet 2 10%*	*Diet 3 20%*	*Diet 4 30%*	*Diet 5 40%*
Dry matter	21.46	20.41	20.35	20.08	20.77	20.07
Crude protein	61.55	66.5	67.08	66.79	67.02	67.29
Crude fat	2.66	2.44	2.41	2.9	2.58	2.46
Crude fiber	6.32	7.28	6.74	6.63	6.69	5.62
Ash	18.02	18.08	17.99	18.64	19.65	19.78
Nitrogen free extract	5.98	5.83	5.97	6.02	5.99	6.10

[*]Dry matter basis.

Discussion

With a common aim of minimizing the use of imported and expensive feed ingredients particularly fish meal to develop low-cost feeds for shrimp, several studies both on marine and freshwater shrimp have evaluated various plant protein meals as replacements for fish meal (Lim and Dominy, 1990; Piedad-Pascual et al., 1990; Tidwell et al., 1993; Peñaflorida, 1995; Lim, 1996; Eusebio and Coloso, 1998; Sudaryono et al., 1999). Feed pea meal was included up to 42% in *P. monodon* diet and did not show adverse effects on growth, feed intake, FCR, survival, and body composition of the shrimp (Bautista-Teruel et al., 2003). Likewise, total replacement of fish meal with soybean meal and distillers' by-products was reported as feasable for freshwater prawn, *Macrobrachium rosenbergii* (Tidwell et al., 1993).

In the present study, inclusion of fermented copra meal (FCM) did not produce any significant differences in the growth data. FCM protein at the highest level of 40% partial replacement for fish meal protein was efficiently utilized by the shrimp as exhibited by the comparable growth and feed efficiency against the control. Results of the feeding trial indicated that the growth pattern of the shrimp for 9 weeks was not significantly altered by feeding diets containing 10-40% partial replacement of fish meal by FCM protein. Previous studies in carp demonstrated that copra meal had a deleterious effect on feed intake and growth performance of the fish (Silva and Weerakon, 1981; Hasan et al., 1997). Copra meal contains anti-nutritional factors, including phytic acid, tannins, and non-starch polysaccharides (Tacon et al., 2009) as well as being poor in essential amino acids, notably lysine and sulphur amino acids (Dairo, 2004; Sundu et al., 2009). This explain its inferior performance as a feed ingredient in other animals. In addition, the high crude fiber content of copra meal is disadvantageous for aquatic feeds (Hertrampf et al., 2000).

However, pre-treatment of copra meal by fermentation eliminates the antinutritional substances it contains and improves its nutritive value and utilization (Dairo, 2006). This is further supported by the results of the present study which showed that dietary FCM had no negative effects on growth and feed performance in shrimp. Fermentation improves the amino acid profile of copra meal (Dairo and Fasuyi, 2007). Fermented copra meal with supplemental amino acids was able to replace 50% dietary fish meal protein and was effectively utilized by rohu fingerlings that resulted in the significant improvement in growth and FCR in the fish (Mukhopadhyay, 2000). Similarly, in laying hens fermented copra meal protein can substitute for 50% of the soybean protein without detrimental effects on their growth (Dairo and Fasuyi, 2008).

Protein efficiency ratio (PER) which measures the protein quality of the diet suggests that protein from FCM is comparable to that of fish meal as demonstrated in the present study. Regardless of the FCM inclusion level in the diet, PER in shrimp was similar. In addition, protein retention in shrimp as exhibited by the protein productive value (PPV) was not influenced by dietary FCM. This indicates that the quality of the amino acids of FCM is as good as that of fish meal and FCM protein is efficiently utilized by the shrimp.

This study demonstrated the potential of fermented copra meal (FCM) as partial replacement for fish meal in shrimp practical diet. Replacement of fish meal by FCM protein up to 40% did not compromise growth, feed efficiency, survival, and body composition of the tiger shrimp, *P. monodon*. Studies on the grow-out phase in larger culture systems are recommended.

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References

Bautista-Teruel M.N., Eusebio P. and T.P. Welsh, 2003. Utilization of feed pea, *Pisum sativum*, meal as a protein source in practical diets for juvenile tiger shrimp, *Penaeus monodon*. *Aquaculture*, 225:121-131.

Cruz-Suarez L.E., Ricque-Marie D., Tapia-Salazar M., McCallum I.M. and D. Hickling, 2001. Assessment of differently processed feed pea (*Pisum sativum*) meals and canola meal (*Brassica* sp.) in diets for blue shrimp (*Litopenaeus stylirostris*). *Aquaculture*, 196:87–101.

Dairo F.A.S. and A.O. Fasuyi, 2008. Evaluation of fermented palm kernel meal and fermented copra meal proteins as substitute for soybean meal protein in laying hens diets. *J. Cent. Eur. Agricult.*, 9(1):35-43.

Dairo F.A.S. and B.K. Ogunmodede, 2004. Performance of laying hens fed coconut meal as replacement for groundnut cake. *Trop. J. Anim. Sci*., 2, 87-90.

Dairo F.A.S., 2006. Evaluation of protein replacement value of sun dried and oven dried coconut oil meal and fermented coconut oil meal in rats. *Int. J. Agric. Res*., 2:246-253.

Eusebio P.S., 1991. Effects of dehulling on the nutritive value of some leguminous seeds as protein sources for tiger prawn, *Penaeus monodon*. *Aquaculture*, 99:297-308.

Eusebio P. and R.M. Coloso, 1998. Evaluation of leguminous seed meals and leaf meals as plant protein sources in diets for juvenile *Penaeus indicus*. *Israeli J. Aquacult.-Bamidgeh*, 40:47-54.

Fox J.M., Lawrence A.L. and E. Li-Chan, 1995. Dietary requirement for lysine by juvenile *Penaeus vannamei* using intact and free amino acid sources. *Aquaculture*, 131(3-4):279–290.

Hasan M.R., Macintosh D.J. and K. Jaunceyn, 1997. Evaluation of some plant ingredients as dietary protein sources for common carp (*Cyprinus carpio* L) fry. *Aquaculture*, 151(1-4):55-70.

Hertrampf J.W. and F. Piedad-Pascual, 2000. *Handbook on ingredients for aquaculture feeds*. Kluwer Academic Publishers, 624 pp.

Kiron V., Phromkunthong W., Huntley M., Archibald I. and G. De Scheemaker, 2012. Marine microalgae from biorefinery as a potential feed protein source for Atlantic salmon, common carp and whiteleg shrimp. *Aquacult. Nutr*., 18(5):521–531.

Knudsen K.E.B., 1997. Carbohydrate and lignin contents of plant materials used in animal feeding. *Anim. Feed Sci. Technol*., 67:319-338.

Lim C., 1996. Substitution of cottonseed meal for marine animal protein in diets for *Penaeus vannamei*. *J. World Aquacult. Soc*., 27:402-409.

Lim C. and W. Dominy, 1990. Evaluation of soybean meal as replacement for marine and animal protein in diets for shrimp *Penaeus vannamei*. *Aquaculture*, 87:53-64.

Mukhopadhyay N., 2000. Improvement of quality of copra (dried kernel of *Cocos nucifera*) seed meal protein with supplemental amino acids in feeds for rohu, *Labeo rohita* (Hamilton) fingerlings. *Acta Ichthyologic et Piscatoria*, 30(2):21-34.

Pascual F.P., 1989. Mineral requirement of penaeids. Advances in Tropical Aquaculture, Feb. 20 – March 4, 1989, Tahiti, AQUACOP IFREMER, *Actes de Colloque*, 9:309-318.

Peñaflorida V.D., 1995. Growth and survival of juvenile tiger prawn fed diets where fish meal is partially replaced with papaya (*Carica papaya* L.) or camote (*Ipomea batatas* Lam.) leaf meal. *Isr. J. Aquacult. Bamidgeh*, 47:25-33.

Piedad-Pascual F., Cruz E.M. and A. Sumalangcay, 1990. Supplemental feeding of *Penaeus monodon* juveniles with diets containing various levels of defatted soybean meal. *Aquaculture*, 89:183-191.

Silva, S.S. and D.E.M. Weerakon, 1981. Growth, food intake and evacuation rates of grass carp (*Ctenopharyngodon idella*). *Aquaculture*, 25:67-76.

Smith D.M., Allan G.L., Williams K.C. and C. Barlow, 2000. Fishmeal replacement research for shrimp feed in Australia. In: L.E. Cruz -Suárez, D. Ricque-Marie, M. Tapia-Salazar, M.A. Olvera-Novoa, R. Civera-Cerecedo (Eds). *Avances en Nutrición Acuícola V. Memorias del V Simposium Internacional de Nutrición Acuícola*., Mérida, Yucatán, México.

Suárez J.A., Gaxiola G.A, Mendoza R., Cadavid G., Garcia G., Alanis G., Suárez A., Faillace J. and G. Cuzon, 2009. Substitution of fish meal with plant protein sources and energy budget for white shrimp *Litopenaeus vannamei* (Boone, 1931). *Aquaculture*, 289: 118-123.

Sudaryono A., Tsvetnenko E. and L.H. Evans, 1999. Evaluation of potential of lupin meal as an alternative to fish meal in juvenile *Penaeus monodon* diets. *Aquacult. Nutr*., 5:277-285.

Sudaryono A., Tsvetnenko E., Hutabarat J. and A. Supriharyono, 1999. Lupin ingredient in shrimp (*Penaeus monodon*) diet: influence of lupin species and types of meals. *Aquaculture*, 171:121-133.

Sundu, B., Kumar, A. and J. Dingle, 2009. Feeding value of copra meal for broilers. World Poult. Sci. J., 65(3):481-491.

Tacon A.G.S. and D. Akiyama, 1997. Feed ingredients. pp. 71-84. In: L.R. D'Abramo, D.E. Conklin, D.M. Akiyama (eds). *Crustacean Nutrition, Advances in World Aquaculture, Volume 6*. World Aquaculture Society, Baton Rouge, Louisiana.

Tidwell J.H., Webster C.D., Yancey D.H. and L.R. D'Abramo, 1993. Partial and total replacement of fish meal with soybean meal and distillers' by-product in diets for pond culture of the freshwater prawn (*Macrobrachium rosenbergii*). *Aquaculture*, 118:119-130.

Triño A.T., Peñaflorida V.D. and E.C. Bolivar, 1992. Growth and survival of *Penaeus monodon* juveniles fed a diet lacking vitamin supplements in a modified extensive culture systems. *Aquaculture*, 101:25-32.

World Bank, 2013. *FISH TO 2030: Prospects for fisheries and aquaculture*. World Bank Report Number 83177-GLB. Agriculture and Environmental Services Discussion Paper 03. Washington, D.C. 20433 USA.