The Asian Journal of Animal Science (December 2009 to May 2010) Vol. 4 Issue 2 : 216-223

RSEARCH PAPER

Growth, biochemial and metabolism response of shrimp, *Penaeus monodon* with processed prawn head waste

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Accepted : October, 2009

ABSTRACT

An attempt was made to test the efficiency of bio-processed prawn head waste added diet on growth, biochemical variation and nutrient metabolism of *Penaeus monodon.* Control (C) and three bioprocessed experimental diets (E1-E3) were prepared by using conventional feed ingredients along with prawn head-waste. Experiments were carried out using *P. monodon* (PL- 20) in one tonne capacity FRP tanks in outdoor experimental set up for a period of 45 days. During this period, the shrimps were fed thrice a day at *ad libitum*. The water quality was maintained in at optimum level in all the tanks and 20 to 30% water exchange was made daily. A constant salinity of 20ppt was maintained throughout the experimental period. The results indicated that the production, SGR, FCR varied significantly between the control and experimental diet fed shrimps. The independent influence of feed quality on variation in carcass biochemical constituents was statistically highly significant ($P < 0.01$). The results on nutrient metabolism also showed the test diet dependent variation. Bioprocessed feed added with prawn head waste also showed a significant ($P < 0.01$) reduction in protein, carbohydrate and lipid loss in the aquaculture environment.

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Key words : Growth, Shrimp, *Penaeus monodon,* Prawn head

A major input in terms of costs in aquaculture is feed. Consequently, aquaculture aims to convert the feed into live fish or shrimp with maximum efficiency. Estimates say, the feed amounts 40 to 60% of the total operating costs in intensive aquaculture. Hence, the formulation of the cost effective and productive feed for the different cultivable species is the major challenge in aquaculture with the view of replacing expensive feed ingredients.

From the nutritional studies available in our country show that the raw materials used are basically rice bran, trash fish meal, wheat flour, fish oil etc. Many less expensive proteins from plant origin have also been studied for complete or partial replacement of fish meal in the shrimp diet (Dabrowski and Kozak, 1979 ; Ferraris *et al.*, 1986 ; Michiels, 1987). There is the possibility in the use of shrimp head (waste) meal, which contains high levels of protein with excellent amino acid profile comparable to that of fish meal. But the utilization of available protein in shrimp head meal by fishes is limited by the presence of substantial quantity of exoskeletal chitin and ash (Bhuiyan, 1989). The need for improvement in the quality of shrimp head waste protein has attracted the application of different processing methods (Fox *et al.*, 1994). Cooking requires excessive use of firewood or other scarce fuels and degrades the lipids, vitamins and pigments content of the shrimp head meal (Fox et a1., 1994). While sun-drying is frequently carried out under unhygienic conditions leading to meals with high microbial loading (Wood, 1982).

Furthermore, marine fishery products are the major source of C2O and C22A-3 fatty acids, which improve survival, growth and stress resistance in the larvae of fish and prawn. Trash fish with crustacean waste is used for fish meal production. It is much used as an aquaculture feed alone, or mixed with other materials, or as part of extruded moist feed. The important marine fishery wastes now-a-days available are mainly fresh fishes, crustacean exoskeleton (shrimp head, lobster head waste) and cephalopod waste such as skin, tentacles, viscera and other parts. If these wastes are properly processed they can be used as the main ingredients of protein rich diet for poultry and in other aquaculture industry. However, only limited number of studies have been made on the estimation of marine fishery waste including fresh fish resources. Considering the informations provided above, the present work was undertaken.

MATERIALS AND METHODS

Collection of animals :

The post larvae (PL20) of tiger shrimp, *Penaeus monodon* were obtained from the Kanai Shrimp

Hatcheries, Kulasekarapatinam, Tuticorin district, Tamil Nadu. The post larvae were transported in oxygenated bags and acclimated to the laboratory conditions in one tonne fibre reinforced plastic (FRP) tanks and maintained with adequate care.

Experimental setup :

Four different groups of *P. monodon* larvae were cultured in one tonne FRP tank @ 30 nos/tank to assess the efficiency of bioprocesed prawn head meal added diets. Among the four tanks, one was used as control tank (C) offered with control diet and the other three tanks were experimental tank, provided with E1, E2 and E_3 diets. The experiment was carried out at 20 ppt salinity for a period of 45 days.

During the experiment period, the shrimps were fed on control and bioprocessed experimental diets added with prawn head meal at the rate of 2 times a day at *ad libitum*. Water quality parameters were maintained by aeration and daily water exchange of 30 to 40% was made. Growth performance and biochemical changes of *P. monodon* were assessed at an interval of 5 days. Changes in muscle protein profile and nutrient metabolism in control (C) and experimental diet fed *P. monodon* were also assessed at the end of the experiment.

Feed ingredients selected for feed preparation :

Locally available inexpensive ingredients such as fish meal, prawn head waste, rice bran, wheat flour, ground nut oil cake and tapioca powder were used. In addition to this, the additives such as stickon, cod liver oil, vitamin and minerals (supradin), sodium chloride and BHT were also used. The composition of the formulated diets are detailed in Table 1.

Prawn head waste :

Pealed prawn head and exoskeleton materials were collected from the pealing centers of various landing areas, cleaned thoroughly using tap water and were sun dried. Then it was ground well and sieved to the required particle size and used for the preparation of test diets.

Bioconversion of feed ingredients :

The feed ingredients listed in Table 1 were weighed into 2000 ml conical flasks according to feed formulation and sterilized to remove the unwanted microbes present if any. Then after cooling, 250 ml of basal medium (KH_2PO_4 – 4g^{-1} ; $NaHPO_4$ – 4 gl^{-1} ; MgSO4 – 0.2 gl^{-1} ; $FeSO_4$ – 0.004 gl^{-1} ; $CaCl_2$ – 0.001 gl^{-1}) 50 ml of chitinolytic microbial broth isolated and screened from the gut of shrimp and 300 ml of distilled water were added

Table 1 : Amount of feed ingredients (g/100g dry weight) used for the preparation of control (C) and experimental feeds (E1 – E3)

Sr. No.	Feed ingredients	Type of feed / Amount of feed ingredients			
		C	E1	E2	E3
1.	Fish meal (g)	135	75	75	75
2.	Groundnut oil cake (g)	78	78	78	78
3.	Soya meal (g)	30	30	30	30
4.	Rice bran (g)	12	12	12	12
5.	Prawn head meal (g)	-	60	60	60
6.	Tapioca powder (g)	15	15	15	15
7.	Wheat flour (g)	15	15	15	15
8.*	Vitamin and minerals (g)	1	1	1	1
9.*	Cod liver Oil (ml)	2	2	2	2
10.*	Stickon (ml)	3	3	3	3
11.*	BHT (g)	1	1	1	1
12.*	Sodium chloride (g)	1	1	1	1

and mixed thoroughly with the help of glass rod and plugged with two vent sponge cork. In one vent of the cork, 5 ml pipette filled with glass wool to a height of 1.0 cm was inserted for the supply of air from the aeration system. The glass wool present in the air flow system would prevent the entry of atmospheric microbes and will avoid the contamination in the bioconversion process. In the second vent of the cork, the glass tube filled with glass wool to a height of 1.0 cm was inserted to remove excess air in the head space to the fermenting vessel. This experimental setup was allowed for bioconversion for different time intervals of 24 h (E_1), 48 h (E_2) and 72 h (E_3). After 24h, 48h and 72h, the fermented feed material was harvested in an enamel tray and that it was sun dried, ground, powdered and used for the preparation of test diets (E_1, E_2 and E3). Simultaneously a control diet (C) was also prepared by using non-bioprocessed feed ingredients devoid of prawn head waste (Fig. 1 and 2).

Feeding preparation :

The bioprocessed, dried and powdered feed ingredients were weighed (300g) and mixed thoroughly and hand kneaded with sufficient quantity of distilled water and made into a dough. The dough was then steam boiled by using pressure cooker for about 20 – 30 min, then cooled and additives such as cod liver oil, vitamin and mineral mix and stick, NaCl and BHT were added to enhance the efficiency of the diet. The control and experimental diets were then extruded in the form of noodles, using a noodle maker pelletizer machine having a perforation diameter of 3 mm. The noodles were dried in sunlight to reduce moisture content and stored in

respective containers. Control feed was prepared without prawn head meal and remaining E_1, E_2 and E_3 diets were prepared with prawn head meal.

Feed stability :

Determination of stability of experimental feed

The stability of the control and experimental diets were estimated by considering percentage leaching as an index of feed stability by immersion method.

A known amount (500 mg) of experimental diets was placed in a glass bowl. The bowls were then immersed separately in a plastic trough containing 1 litre of water for a period 1, 2, 4 and 6 h. Each lot of bowl was removed from the trough after the time interval without spilling the feed materials. Water from each bowl was drained carefully using No. 30 blotting silk cloth and the residue was dried in sun for 30 min. Then the mean weight before immersion and after drying were measured and used to calculate the percentage of the dry matter loss and it was considered as the measure of water stability of the experimental feed for the corresponding time interval.

Feeding :

The prepared feeds were offered to the candidate species of an intervals of two times daily to satiation. The control feed for control tank and experimental feed (E1 to E3) for experimental tank 1, 2 and 3 were offered. Feed consumption was monitored and adjusted based on the demand.

Water quality analysis :

The present study was carried out over a period of 45 days. Water samples were collected once in 5 days from the control (C) and experimental tanks (E_1, E_2 and E_3). Aeration was given continuously in order to keep the oxygen content at the optimum level. The salinity of all the tanks were maintained at 20 ppt. The temperature, pH, oxygen and ammonia levels in culture tanks were maintained at their optimum level and were recorded once in 5 days (Table 2).

Table 2 : Average water quality parameters recorded in control tank (C) and experimental tanks (E_1 – E_3) during 45 days of culture period

FRP tanks	Water quality parameters				
	Temperature (^{0}C)	Salinity (ppt)	DO (mg/l)	pH	NH_3 (mg/l)
Control (C)	29.1	20	5.528	8.36	2.254
E_1	29.2	20	5.400	8.401	3.283
E_2	28.3	20	5.402	8.54	3.311
E_3	28.5	20	5.993	8.46	3.138

Growth parameters :

To find out the growth, weight of the shrimp in control and experimental tanks were measured during 25th and 45th days of the experiment.

Weight (g) :

Weight was taken by using electrical balance with least disturbance to the shrimp.

Production (Growth) :

Production (g) = Final wet weight – Initial wet weight

Food consumption :

Food consumed (g)=Food provided – uneaten food remains

Food conversion efficiency (FCE) :

$$\text{FCE}(\%) = \frac{\text{Wet wt. of the fish produced (g)}}{\text{Drywt.ofthefeedgiven(g)}} \text{x100}$$

Absolute growth rate (AGR) :

$$\text{AGR(g/bodywt./day)} = \frac{\text{Final body wt. – Initial body wt.}}{\text{Total number of days}}$$

Specific growth rate (SGR) :

$$\text{SGR}(\%) = \frac{\text{Final wet weight – In Initial wet weight}}{\text{Experimental duration}} \text{x100}$$

Food conversion ratio (FCR) :

$$\text{FCR} = \frac{\text{Dry wt. of feed given (g)}}{\text{Increase in wt. of fish (g)}}$$

Survival :

To find out the effect of herbal feed AquaImmu on shrimp *P. monodon*, survival was monitored and the percentage was calculated as follows.

$$\text{Survival}(\%) = \frac{\text{Total number of shrimps on initial day} - \text{Total number of mortality}}{\text{Initial number of shrimp}} \text{x100}$$

Collection of tissue :

To find out the variation in biochemical changes in the muscle tissue of experimental animal, *Penaeus monodon*, it was dissected out under aseptic conditions. After collecting the tissue, the tissue of four samples were kept in separate sterilized vials marked and stored in deep freezer until further use.

Biochemical analysis :

The contents of protein, lipid and carbohydrate of muscle tissue of *Penaeus monodon* were estimated on 25th and 45th day. Feed samples were also analysed for protein, lipid and carbohydrate levels.

RESULTS AND DISCUSSION

The results obtained from the present investigation are summarized below :

Experimental diets :

For the present study altogether four diets were prepared by using convention feed ingredients and also with bioprocessed prawn head meal. A control diet was also prepared without bioprocessed prawn head meal (C). The experimental diets E_1, E_2 and E_3 were prepared with bioprocessed conventional feed ingredients added with prawn head meal for various time intervals of 24, 48 and 72 h. The biochemical constituents of the control and experimental diets are provided in Table 2. The protein content of the test diets varied between 36.69 ± 0.41 and 38.40 ± 0.75 mg/100mg dry weight. Likewise the carbohydrate and lipid contents, respectively varied from 15.99 ± 0.20 to 18.17 ± 0.25 mg/100 mg dry weight and from 8.78 ± 0.21 to 9.16 ± 0.23 mg/100 mg dry weight (Table 3).

Survival :

The survival of *P. monodon* fed with control and experimental diets (E_1 to E_3) were also monitored and recorded (Fig. 1). The survival was high (100%) for *P. monodon* received diets containing bioprocessed prawn head meal (E_1 to E_3). In control diet fed shrimps, the survival was low (98%).

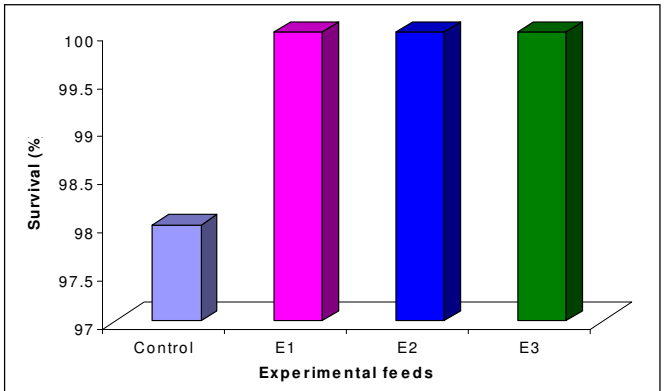

Fig. 1 : Survival (%) of *P. monodon* fed with control and bioprocessed prawn head meal added diets

Growth responses :

The overall growth responses were also calculated for *P. monodon* fed with control and E_1 to E_3 diets. The initial and final weights during the overall experimental period varied between 0.009 to 0.65g, 0.007 to 0.7g, 0.008 to 0.73g and between 0.010 to 0.8g, respectively in shrimps fed with control (C), E_1, E_2 and E_3 diets. The maximum production of 0.79g was registered in *P. monodon* fed E3 diets. The food consumption was minimum in *P. monodon* fed E_3 feed (1.72g) and maximum in E_1 (1.99g). The food conversion efficiency were minimum in control (C) (32.57%) and maximum (45.59%) in E_3 diet fed shrimps. The specific growth rates varied from 9.510 to 10.230% in shrimp fed with control feed, E_1, E_2 and E_3 diets. The food conversion ratio varied between 2.18 and 3.04 in shrimp fed with control and experimental feeds

Table 3 : Biochemical composition (% dry weight) of the control and bioprocessed prawn head meal added diets

Biochemical composition (% dry weight)	Control	E1	E2	E3
Protein	37.02 ± 0.55	37.07 ± 0.53	36.69 ± 0.41	38.40 ± 0.75
Carbohydrate	16.94 ± 0.19	18.17 ± 0.25	17.05 ± 0.28	15.99 ± 0.20
Lipid	9.1 ± 0.18	8.78 ± 0.21	9.16 ± 0.23	9.06 ± 0.19

Each value (X ± SD) is the mean of three individual estimates

Table 4 : Overall growth responses of *P. monodon* fed with control and bioprocesed prawn head meal added diets

Parameters	Control	Experimental feed		
		E1	E2	E3
Initial weight (g)	0.009	0.007	0.008	0.010
Final weight (g)	0.650	0.700	0.730	0.800
Production (g)	0.641	0.693	0.722	0.790
Food consumed (g)	1.950	1.990	1.910	1.720
Food conversion efficiency (%)	29.540	31.810	33.180	36.600
Specific growth rate (%)	5.177	5.571	5.460	5.301
Food conversion ratio	3.040	2.870	2.640	2.180

Each value is the mean of three individual estimates

(E_1 to E_3) (Table 4).

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Each value is the mean of three individual estimates

Carcass biochemical composition :

The influence of dietary bioprocessed prawn head meal on variation in deposition of organic constituents in the muscle tissue of *P. monodon* was also investigated. The data on the protein, carbohydrate and lipid in the muscle tissue of the *P. monodon* fed with control and prawn bioprocessed prawn head meal added diets are presented in Table 5. The results indicated that the deposition of tested biochemical constituent in the muscle tissue of *P. monodon* varied much during the experimental period as well as varied between feeds. For instance, in control feed fed shrimp, the protein content varied from 38.42 mg/100 mg dry tissue to 43.04 mg/100 mg dry tissue. Likewise in shrimp fed with experimental diets (E_1 to E_3), the protein content varied from 41.46 mg/100 mg dry tissue to 45.47 mg/100 mg dry tissue in E_1 diet from 43.44 to 47.51 mg/100 mg dry tissue in experimental diet E_2 and 44.84 mg/100 mg dry tissue to 48.33 mg/100 mg dry tissue in experimental diet E_3, respectively (Table 5).

The carbohydrate content varied from 0.18 ± 0.024 to 2.791 ± 0.281 mg/100 mg wet tissue from 1.389 ± 0.25 to 3.28 ± 0.48 mg/100 mg wet tissue, from 1.859 ± 0.27 to 3.21 ± 0.62 mg/100 mg wet tissue and from 1.869 ± 0.37 to 3.51 ± 0.18 mg/100 mg wet tissue, respectively in control, E_1, E_2 and E_3 diet fed shrimps (Tables 5).

Likewise, the lipid content fluctuated from 0.662 ± 0.05 to 1.710 ± 0.03 mg/100 mg wet tissue, from 0.756 ± 0.04 to 2.372 ± 0.07 mg/100 mg wet tissue, from 0.682 ± 0.01 to 2.513 ± 0.17 mg/100 mg wet tissue and from 0.971 ± 0.06 to 2.721 ± 0.18 mg/100 mg wet tissue, respectively in control, E_1, E_2 and E_3 diet fed shrimps (Table 5).

Two-way analysis of variance for the data on variation in tested biochemical constituents as a function of quality of test diets and experimental duration inferred that, both these variables significantly ($P < 0.05$ to $P < 0.01$) influenced the variation in protein content, whereas for carbohydrate and lipid, the independent influence of variance due to feed quality was also statistically significant ($P < 0.01$).

Nutrient metabolism :

The influence of bioprocessed prawn head meal added diets on variation in nutrient utilization was also assessed in *P. monodon*. In control feed fed shrimp, protein consumption was 0.721 mg dry weight. Likewise, in experimental diets (E_1 to E_3) fed shrimps the protein consumption varied from 0.660 to 0.737 mg dry weight, respectively (Table 6). The protein production recorded were 0.247, 0.248, 0.270 and 0.302 mg dry weight, respectively in control, E_1, E_2 and E_3 diet fed shrimps. The protein gain of *P. monodon* fed with control diet (C) was 21.21 mg dry weight and in those shrimps fed on experimental diets (E_1, E_2 and E_3) the values recorded were 24.61, 27.30 and 30.36 mg dry weight, respectively.

Similarly, the protein retention of *P. monodon* fed with control diet (C) was 57.29 mg dry weight. But in those shrimps fed experimental diets (E_1 to E_3), the values recorded were, 66.38, 73.94 and 78.28 mg dry weight, respectively. The protein loss was minimum (21.72%) in E_3 diet fed shrimps, whereas, it was maximum in control diet (42.71%) fed groups (Fig. 2). The trend noticed for

Table 5 : Carcass biochemical constituents protein (mg 100mg^{-1} dry wt), carbohydrate and lipid (mg 100 mg$_{-1}$ wet weight) of *P. monodon* fed on control (C) and experimental diets (E_1 – E_3) during the experimental duration

Feeds	Carcass biochemical constituents at various experimental duration								
	Protein			Carbohydrate			Lipid		
	Initial	25	45	Initial	25	45	Initial	25	45
Control	38.42 ± 0.45	41.75 ± 0.52	43.04 ± 0.59	0.869 ± 0.15	2.791 ± 0.28	2.51 ± 0.21	0.641 ± 0.05	1.454 ± 0.01	1.687 ± 0.09
E_1	40.06 ± 0.47	41.46 ± 0.53	45.47 ± 0.60	0.912 ± 0.16	2.313 ± 0.25	3.13 ± 0.18	0.734 ± 0.08	2.087 ± 0.06	2.32 ± 0.10
E_2	40.82 ± 0.98	43.44 ± 0.67	47.51 ± 0.73	0.929 ± 0.25	2.716 ± 0.32	3.21 ± 0.62	0.668 ± 0.16	2.386 ± 0.04	2.41 ± 0.15
E_3	39.20 ± 0.62	44.84 ± 0.83	48.33 ± 1.17	1.336 ± 0.32	2.781 ± 0.61	3.51 ± 0.18	0.453 ± 0.09	2.521 ± 0.17	2.63 ± 0.17

Each value is the mean ± SD of three individual estimates

the carbohydrate consumption of *P. monodon* fed control and experimental diets (E_1 to E_3) was similar to that of recorded for protein utilization. The carbohydrate consumption of *P. monodon* fed with control diet was 0.330 mg dry weight. Likewise in experimental diets (E_1 to E_3) fed shrimps, the protein consumption varied from 0.275 to 0.361 mg dry weight (Table 6).

The carbohydrate production of *P. monodon* fed control and experimental diets were 0.017, 0.022, 0.023 and 0.027 mg dry weight. By the same way, the carbohydrate gain of *P. monodon* fed with control diet (C) was 7.565 mg dry weight ; whereas in experimental diets (E_1, E_2 and E_3) fed shrimps the higher values of 9.892, 0.83 and 12.32 mg dry weight, respectively were recorded (Table 7).

The carbohydrate retention of *P. monodon* fed with control diet (C) was low (44.65 mg). But in experimental diets (E_1 to E_3) fed *P. monodon,* the higher values of 54.44, 63.51 and 77.04 mg dry weight were registered. The loss in carbohydrate was minimum (22.96%) in E_3 diet fed *P. monodon* and it was maximum (55.35%) in control diet fed shrimps (Fig. 2).

Likewise, the lipid consumption of *P. monodon* fed control (C) and experimental diets (E_1 to E_3) ranged between 0.155 mg and 0.177 mg. The lipid production of *P. monodon* was low (0.010 mg dry weight) in control diet fed shrimps. But in experimental diets (E_1 to E_3) fed shrimps, a higher production range of 0.016 to 0.018 mg dry weight was noticed. Similarly the lipid gain of *P. monodon* fed with control diet (C) was 5.084 mg dry weight and in experimental diets (E_1, E_2 and E_3) the values recorded were 7.331, 7.82 and 8.488 dry weight, respectively (Table 8).

The lipid retention of *P. monodon* fed with control diet (C) was low (55.86%), whereas, in experimental diets fed group the higher values of 83.49% (E_1), 85.37% (E_2) and 93.62% (E_3) were registered. The loss in dietary lipid was minimum (6.38) in E_3 diet fed groups and it was maximum (44.14%) in control diet fed groups (Fig. 2).

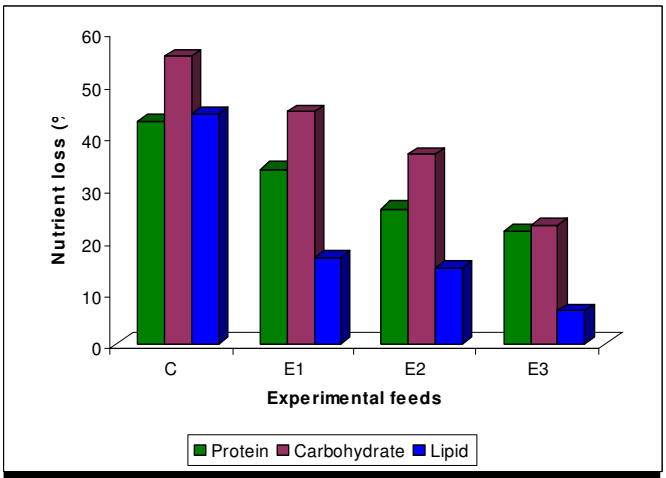

Fig. 2 : Feed nutrient loss of *P. monodon* fed control and experimental diets added with bioprocessed prawn head waste

Any type of fish culture operation always leads to release into the environmental water of both organic and inorganic nutrients through branchial and urinary or faecal loss together with feed wastes. The organic nutrients cause oxygen deficit condition while inorganic compounds such as phosphate and ammonia lead to eutrophication. Therefore, there is a growing consense that complies with regulations and limits the so called self-pollution.

Normally, in aquaculture system, water quality is the main criterion that affects the physiological status of the

Table 6 : Protein turnover in the culture of *P. monodon* fed control and bioprocessed prawn head meal added diets

Test diets	Protein consumed (mg dry wt)	Protein production (mg dry wt)	Protein gain (mg dry wt)	Protein retention (%)
Control	0.721 ± 0.039	0.217 ± 0.010	21.21 ± 0.98	57.29 ± 2.86
E_1	0.737 ± 0.042	0.248 ± 0.019	24.61 ± 0.97	66.38 ± 3.72
E_2	0.700 ± 0.038	0.270 ± 0.020	27.13 ± 1.28	73.94 ± 2.87
E_3	0.660 ± 0.058	0.302 ± 0.010	30.36 ± 1.31	78.28 ± 3.67

Each value (X ± SD) is the average of three individual estimates

Table 7 : Carbohydrate turnover in the culture of *P. monodon* fed control and bioprocessed prawn head meal added diets

Test diets	Carbohydrate consumed (mg dry wt)	Carbohydrate production (mg dry wt)	Carbohydrate gain (mg dry wt)	Carbohydrate retention (%)
Control	0.330 ± 0.021	0.017 ± 0.001	7.565 ± 0.478	44.650 ± 2.320
E_1	0.361 ± 0.034	0.022 ± 0.003	9.892 ± 0.512	54.440 ± 1.870
E_2	0.351 ± 0.041	0.230 ± 0.002	10.830 ± 0.730	63.510 ± 3.140
E_3	0.275 ± 0.018	0.027 ± 0.003	12.320 ± 0.920	77.040 ± 3.780

Each value (X ± SD) is the average of three individual estimates

Table 8 : Lipid turnover in the culture of *P. monodon* fed control and bioprocessed prawn head meal added diets

Test diets	Lipid consumed (mg dry wt)	Lipid production (mg dry wt)	Lipid gain (mg dry wt)	Lipid retention (%)
Control	0.177 ± 0.004	0.010 ± 0.0006	5.084 ± 0.283	55.86 ± 3.12
E_1	0.174 ± 0.006	0.016 ± 0.0003	7.331 ± 0.371	83.49 ± 3.97
E_2	0.174 ± 0.003	0.018 ± 0.0005	7.82 ± 0.710	85.37 ± 4.82
E_3	0.155 ± 0.002	0.021 ± 0.0004	8.488 ± 0.478	93.62 ± 3.72

Each value (X ± SD) is the average of three individual estimates

organisms. Kurmaly and Guo (1996) found that environmental stresses such as high ammonia, low temperature and low dissolved oxygen significantly altered the physiological, biochemical changes and also resistance. *P. monodon* was cultured in one tonne capacity FRP tanks; wherein, the water quality parameters were maintained at the optimum level and also uniformly in all the culture tanks. This finding is supported by results from Bray *et al.* (1994), however, it is not in agreement with Huang (1983) in a 30 days laboratory trial with PL of *P. monodon*. In their study, the best growth obtained was at about 20 ppt while poorest results were obtained at 5 and 45 ppt. The presence of antioxidants like a-tocopherol in the diet prevent the oxidation and thus is found to be important for maintenance of quality of PUFA in the diet.

Quiet interestingly, the addition of bioprocessed prawn head meal in the diet enhanced the growth performance of *P. monodon* in the present study. This variation was noticed during 45th days of the experiment. The overall growth performance indicated that the maximum growth (0.8g), food consumption (1.99g), SGR (5.571%) and FCR (2.18) were recorded in *P. monodon* received diet containing 30g bioprocessed prawn head meal per 100 g feed. Shrimp fed with diets containing the same 30 g bioprocessed prawn head meal / 100g feed but bioprocssed for 24 h was also displayed better growth performance in bar with those received diets containing 72 h bioprocessed prawn head meal. The results find support from the earlier work of Sung *et al.* (1994). They showed that tiger shrimp grow better when immersed in *V. vulnificus* bacterium than those in control group. They also reported that, when as shrimps were immersed in a glucon suspension at a concentration of 0.1, 1.0 and 2 mg.ml^{-1}, displayed better growth than at 0.2 mg/ml^{-1} and control suspension (Sung *et al.*, 1994).

A low cost raw material, prawn head waste was used in the present study for the production of aqua feed. Compared with other convention feed ingredients, it is relatively cheap and also it is biologically safe. This can be done on large scale using simple techniques because no cost effective instruments are involved in their process. The time taken for its production is also relatively short. Moreover, the ingredients produced from the fermented material contain protein, carbohydrate and lipids in bioavailable from which may support the growth of animals.

The bioprocessed materials which was added to the diets was easily utilized by the animals and was very suitable for enhancing growth parameters. It clearly showed that the bioconversion of feed ingredients was very much essential for enhancing the growth of animal. This is the obvious reason for the displacement of better growth performance by *P. monodon* fed with bioprocessed prawn head meal added diet.

Bioprocessed prawn head meal added diets also altered the variation in carcass biochemical constituents of *P. monodon*. The tested biochemical constituents such as protein, carbohydrate and lipid contents were high in those shrimps fed with test diets when compared to those received control diet. Statistical analysis indicated that, the influence of feed quality in the present study was highly significant ($P < 0.01$) for all the tested parameters. It clearly indicated the influence of bioprocessed feeds on the synthesis of biochemical constituents.

The results obtained on the nutrient metabolism of *P. monodon* also indicated the efficiency of bioprocessed feed ingredient on nutrient turnover and loss. The protein gain / retention was high in E_3 diet fed shrimp (30.36 ± 1.31 mg dry weight / 78.28 ± 3.67%) and it was very low (21.21 ± 0.98 mg dry weight / 57.29 ± 2.86%) for control diet fed groups. Likewise, the carbohydrate gain / retention was maximum (12.32 ± 0.92 mg dry weight / 77.05 ± 3.78%) in E_3 diet fed shrimps. The trend was also continued for lipids, where in the maximum gain / retention (8.488 ± 0.478 mg dry weight / 93.62 ± 3.72%) was noticed in the same E_3 diet fed shrimps. In accordance with the protein / carbohydrate / lipid gain / retention, the loss of these nutrients was also varied much and obviously it was low in those shrimps fed with E_3 diet. In this diet (E_3) the loss of protein, carbohydrate and lipid, respectively were 21.72%, 22.96% and 6.38%. This value was 42.71 to 55.35% low when compared to the values recorded in those shrimps fed with control diet.

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