



Growth and survival of *Macrobrachium rosenbergii* (de Man) post larvae fed with iso-proteic diets incorporated with fishmeal and its substitution exclusively by plant protein

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The production of fish meal and fish oil remains almost constant but its demand has been increasing @ 10% per year (Amaya *et al.* 2007, Suárez *et al.* 2009). Non-availability of quality fish meal at reasonable cost, challenges the farmer's profitability in prawn farming. Currently, research has been focused to replace fish meal partially or fully by suitable protein-rich ingredients in the feed of shrimps and prawn (Ali and Sahu 2002, Alvarez *et al.* 2007, Suárez *et al.* 2009). One of the possible ways to reduce the cost of aquafeed and to increase the profitability is the incorporation of less expensive high quality plant protein resources as the substitute of fish meal (Mohanty and Rath 2008). Different kinds of oil cakes and soybean meal are the cheap source of protein and lipid including essential amino acids and fatty acids. Therefore, nutritionally balanced cost-effective aquafeeds could be developed by incorporating some of these ingredients. Present study is aimed to replace the fish meal with cost-effective plant ingredients for nursery rearing of *M. rosenbergii* post larvae in pond condition.

Feed formulation: Three different iso-proteic (350 g protein kg⁻¹ diet) farm made test feeds with 6.0% lipid were prepared. In feeds A and B, the fish meal was incorporated @ 15 and 7.5%, respectively and in feed C, the fish meal was completely substituted by plant based ingredients. The ingredients and chemical composition (g kg⁻¹ dry matter basis) of the experimental diets is presented in Table 1.

Feeding trial: The feeding experiment was conducted for a period of 45 days at the Institute. Twenty days old hatchery produced post larvae (PL) of *M. rosenbergii* were reared in nine nylon hapas (2.5 m × 1.0 m × 1.0 m) of 0.8 mesh/mm², fixed in a 0.04 ha nursery pond to evaluate nutritional performance of each experimental diet in triplicate groups. The prawn PL were stocked at 100/m³ in each hapa and fed

Table 1. Ingredients and chemical composition (g kg⁻¹ dry matter basis) of the experimental diets (mean±SE)

Ingredients	Feeds		
	Feed A	Feed B	Feed C
Groundnut oil cake	200	200	200
Soybean meal	370	445	540
Fish meal	150	75	—
Rice polish	250	240	230
Wheat flour	10	10	10
Vitamin-mineral pre-mix*	20	20	20
<i>Chemical composition</i>			
Crude protein	352.3±0.7 ^a	351.3±0.5 ^a	349.8±1.7 ^a
Ether extract	63.1±1.1 ^a	57.8±0.5 ^a	56.2±2.8 ^a
Crude fibre	90.0±0.2 ^a	90.2±0.6 ^a	86.8±1.4 ^a
Ash	145.0±0.5 ^a	128.9±0.2 ^b	117.3±2.9 ^c
Nitrogen free extract	349.6±0.5 ^c	371.8±1.5 ^b	389.7±3.9 ^a

Mean bearing different superscripts in a row differ significantly (P<0.05). * Each 1 kg contains: vitamin A: 200000 IU, vitamin D₃: 40000 IU, vitamin B₂: 0.8 g, vitamin E: 300 IU, vitamin K: 400 g, calcium panthionate: 1 g, nicotinamide: 4 g, vitamin B₁₂: 2.4 mg, choline chloride: 60 g, calcium: 300 g, manganese: 11 g, iodine: 0.4 g, iron: 3. g, zinc: 6 g, copper: 0.8 g, cobalt: 0.18 g.

with test diets crumbles (0.3–0.5 mm size) at 30% of their total body mass for 1 week. Second week onwards, the feeding rate was increased @ 30% of the preceeding week. The feed was applied in 2 equal split doses. All the hapas were cleaned from outside at weekly interval by means of a plastic bush to prevent the algal clogging.

Data collection and analysis: After 45 days of rearing, the juveniles were harvested and data were collected for analysis. The live weight gain (%), specific growth rate (SGR, % day⁻¹), food conversion ratio (FCR), protein efficiency ratio (PER), net protein utilization (NPU%) and survival rate (%) were calculated. The analysis of proximate composition of feed and whole body prawn larvae were done by standard procedures (AOAC 1990). Dry matter was

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obtained by drying the samples at 105°C for 24 h. Crude protein (CP) was assessed by Kjeldahl method ($N \times 6.25$) and crude lipid (CL) by petroleum ether extract with Soxhelt method. Ignition of samples was done at 550°C for 3 h in a muffle furnace to determine the ash value. Water quality parameter was analyzed following the standard procedure (APHA 1989). Data were analyzed by using one-way ANOVA (Snedecor and Cochran 1967) and differences between means were tested using Duncan's multiple range test.

The water quality parameter of the pond was monitored on weekly basis and maintained within the optimum range. There was no significant difference ($P>0.05$) in crude protein, ether extract and crude fibre content among 3 test feeds. The ash content of the test feeds showed higher value in the feed which contained higher % of fish meal and the lowest ash content is found in the feed without fish meal supplementation. The trend of NFE was in reverse order with that of ash content. Mean length, weight, survival and FCR, weight gain, SGR, PER and NPU are presented in Table 2. The per cent weight gain of PL fed with different feeds had significantly different ($P<0.05$) with a maximum in feed C followed by feed B and A. However, the difference is not significant ($P>0.05$) between feed B and C. The SGR of different feeding groups were significantly different ($P<0.05$) and it was maximum in feed C followed by feeds B and A. However, the difference was not significant ($P>0.05$) between feed B and C. The PER showed significant difference ($P<0.05$) among the 3 experimental fish groups; highest in feed C, followed by feeds B and A. Moreover, net protein utilization (NPU%) was also significantly different ($P<0.05$) among the feeding groups. There was no significant difference ($P>0.05$) in the survival rate between different feeding groups. But the difference was a significant difference

Table 2. Growth parameters and nutritional indices of *M. rosenbergii* PL reared in test feeds

Ingredients	Feeds		
	Feed A	Feed B	Feed C
Initial length (mm)	15.1±0.17 ^a	15.1±0.17 ^a	15.1±0.17 ^a
Final length (mm)	38.7±0.55 ^b	44.9±0.73 ^a	42.8±0.66 ^a
Initial weight (g)	0.028±0.01 ^a	0.028±0.01 ^a	0.028±0.01 ^a
Final weight (g)	0.443±0.62 ^b	0.623±0.02 ^a	0.640±0.02 ^a
Survival (%)	87.06±1.48 ^a	86.66±0.88 ^a	87.46±1.57 ^a
FCR	3.8±0.02 ^b	2.9±0.06 ^a	2.6±0.1 ^a
Weight gain (g)	0.42±0.01 ^b	0.58±0.03 ^a	0.61±0.01 ^a
Weight gain (%)	1482.14 ±16.1 ^b	2064.28 ±119.75 ^a	2165.35 ±44.84 ^a
SGR (% day ⁻¹)	0.92±0.01 ^b	1.28±0.07 ^a	1.35±0.03 ^a
PER	0.74±0.01 ^b	1.06±0.02 ^a	1.10±0.04 ^a
NPU (%)	15.24±0.62 ^b	22.19±2.07 ^a	24.78±1.15 ^a

The data are mean±SE. Mean bearing different superscripts in a row differ significantly ($P<0.05$).

Table 3. Whole body chemical composition of *M. rosenbergii* post larvae and juveniles fed with different diets (g kg⁻¹ dry matter basis)

Parameters	Initial (PL)	Feed A	Feed B	Feed C
Moisture	705.3±1.3 ^a	699.3±1.5 ^a	695.3±5.7 ^a	683.2±2.3 ^b
Crude protein	653.4±1.9 ^c	679.8±4.1 ^b	679.6±0.6 ^b	703.1±2.2 ^a
Ether extract	88.5±1.5 ^b	92.2±4.5 ^b	99.1±0.6 ^{ab}	106.4±5.2 ^a
Ash	218.9±1.73 ^a	199.4±3.49 ^b	192.4±1.39 ^b	182.1±3.49 ^c

The data are mean±SE; mean bearing different superscripts in a row differ significantly ($P<0.05$).

($P<0.05$) in FCR between the different diet fed groups with minimum in C followed by B and A and nonsignificant ($P>0.05$) among B and C groups. Although there is no significant difference ($P>0.05$) in whole body protein content in different diet fed groups, the maximum protein content was in feed C, which may have resulted in higher PER and NPU (Tables 2 and 3). The whole body lipid content also showed similar trend like protein. However, the whole body ash content was comparatively lower in fish fed feed C than feed A and B. Although the test diets were prepared in an experimental scale, a simple economic analysis showed that the on farm cost of the diet kg⁻¹ is lowest (INR 13.91) for feed C followed by feeds B (INR 15.07) and A (INR 16.24).

Fish meal available in India is mostly produced from marine by catch, which contains more amount of scales and bones than fish flesh. The usual practice of on-shore drying process of fish to produce fish meal resulted enough scope to retain a good amount of silica in fish meal (Giri *et al.* 2010). With increase in the fish meal content, there is an increase in ash content in the feed, which is reflected in the chemical composition of experimental feeds. Lemos *et al.* (2000) suggested that soybean meal is one of the most suitable alternatives of animal protein in the crustacean diet due to its easy availability, reasonable price and good digestibility. Suárez *et al.* (2009) did not find any difference in growth and survival of *Litopenaeus vannamei* in the test feeds incorporated with 6, 10 and 15% fish meal. Markey *et al.* (2011) while working with *Litopenaeus vannamei* juvenile reported similar performance by replacing animal protein with soybean meal and distillers grain soluble in the feeds. Florito *et al.* (2000) emphasized on the suitability of soybean as substitute of fish meal. These above findings are in agreement with our results. However, in contrast to our findings, Du and Niu (2003) reported that although the feed intake was not affected, there was no improvement in SGR and FCR when *M. rosenbergii* were fed the diets containing the increasing level of soybean. Abdel Rahman *et al.* (2010) indicated that the diet in which 40% fish meal was replaced by soybean meal gave similar growth and production, and was cost-effective for culture of *Metapenaeus monoceros* juveniles. Manuel *et al.* (2008) reported that for juvenile of *M. tenellium*, the total replacement of fish meal by soybean

meal did not have any significant difference in SGR, standard length and % weight gain and therefore, the fish meal can be replaced by soybean meal in formulating the prawn nursery diets. In this study, soybean meal based feed showed better growth performance over the feed where fish meal is incorporated at 15% level. Hassanuzzaman *et al.* (2009) found that less incorporation of fish meal in feed and replacement of the same by soybean meal resulted in better FCR, PER and SGR in low salinity grow out ponds of *M. rosenbergii* which corroborates with our findings. Suárez *et al.* (2009) reported that incorporation of soybean meal at 40% in diet of *Litopenaeus vannamei* could replace fish meal completely in a pond rearing system. They justified that although there was no animal source of protein in the diet, the nutrient from phytoplankton and zooplankton might have contributed for growth and survival. In this study, feed C, which is completely free from fish meal performed better than the diet A containing fish meal at 15% level. This may be due to the contribution of plankton in the nursery pond, which might have served as animal protein for rearing the prawn post-larvae. Similar to our findings on survival of prawn post-larvae, Muzinic *et al.* (2004) also reported no difference in survival rate in crayfish culture while fish meal protein is replaced by plant protein. In the present study, the cost of the fish meal free diet (feed C) was lowest (INR 13.91 kg⁻¹) over feed B (INR 15.07 kg⁻¹) and feed A (INR 16.24 kg⁻¹), where the fish meal was used at 7.5 and 15%, respectively.

SUMMARY

M. rosenbergii post-larvae were reared for 45 days in ponds using net hapa (2.5 m × 1.0 m × 1.0 m) of 0.8 mesh/mm² and fed with 3 iso-proteic (35%) and iso-lipid (6%) feeds. Feed A and B contained 15 and 7.5% fish meal, which was totally replaced by soybean meal in feed C. At the end of the rearing period, there was a significant difference in weight of prawn larvae among different diets fed groups with a maximum in feed C (0.64±0.02 g) followed by feed B (0.62±0.72 g) and feed A (0.44±0.01 g). Survival (%) of prawn larvae in different feed groups did not differ significantly. SGR (% day⁻¹) differed significantly among the experimental groups and the highest was recorded in feed C (1.35±0.30) followed by feed B (1.28±0.07) and feed A (0.99±0.01). Apparent FCR of feed C was significantly lower than feed B and feed A. The PER of feed C (1.1±0.04) and feed B (1.06±0.02) was significantly higher than feed A (0.74±0.01). Similarly, the NPU was significantly higher in feed C groups followed by feed B and feed A groups. The cost of feed C was lowest (INR 13.91) than feed B (INR 15.07) and C (INR 16.24). The results of this experiment revealed that fish meal could be completely replaced by soybean meal in the feeds for nursery rearing of *M. rosenbergii* without hampering the growth, dietary performances and survival of prawn larvae.

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REFERENCES

- Abdel Rahman S H, Abdel Razek F A, Goda A M A S, Ghobashy A F A, Taha S M and Khafagy A R. 2010. Partial substitution of dietary fish meal with soybean meal for speckled shrimp, *Metapenaeus monoceros* (Fabricius 1798) (Decapoda: Penaeidae) juvenile. *Aquaculture Research* **41**: 299–306.
- Ali S and Sahu N P. 2002. Response of *Macrobrachium rosenbergii* (de Man) Juveniles to fish silage as substitutes for fish meal in dry diets. *Asian fisheries Science* **15**: 61–71.
- Alvarez J S, Hernandez-Liama A, Galindo J, Fraga L, Gracia T and Villrreal H. 2007. Substitution of fishmeal with soybean meal in practical diets of juvenile white shrimp *Litopenaeus schmitti* (Perez-Farfante & Kensley 1997). *Aquaculture Research* **38**: 689–95.
- Amaya E A, Davis D A and Rouse D B. 2007. Replacement of fish meal in practical diets for the Pacific white shrimp *Litopenaeus vannamei* reared under pond condition. *Aquaculture* **262**: 393–401.
- AOAC. 1990. *Official Methods of Analysis*. Pp 69–78. Arlington.
- APHA. 1989. *Standard Methods for the Examination of Water and Waste water*. Pp.1193. APHA New York.
- Du L and Niu C J. 2003. Effect of dietary substitution of soybean meal for fish meal consumption, growth and metabolism of juvenile giant freshwater prawn, *Macrobrachium rosenbergii* *Aquaculture Nutrition* **9**: 139–43.
- Floreto E A, Bayer R C and Brown P B. 2000. The effect of soybean-based diets with and without amino acid supplementation on growth and biochemical composition of juvenile American lobster, *Homarus americanus*. *Aquaculture* **189**: 211–35.
- Giri S S, Sahoo S K and Mohanty S N. 2010. Replacement of by-catch fish meal with chicken viscera meal in extruded feed: effect on growth, nutrient utilisation and carcass composition of catfish *Clarias btrachus* (Linn.) fingerlings. *Aquaculture International* **18**: 539–44.
- Hasanuzzaman A F M, Md. Siddiqui N and Chisty A H. 2009. Optimum replacement of fish meal with soybean meal in diet for *Macrobrachium rosenbergii* (De Man 1879) cultured in low saline water. *Turkish Journal of Fisheries and Aquatic Sciences* **9**: 17–22.
- Lemos D J, Ezquerro M and Gracia-Carreno F I. 2000. Protein digestion in Penaeid shrimp: digestive proteinases inhibitors and feed digestibility. *Aquaculture* **186**: 89–105.
- Manuel G G, Lopez-Aceves L A, Ponce-Palafox J T, Rodriguez-Gonzalez H and Arredondo-Figueroa J L. 2008. Growth of freshwater prawn *Macrobrachium tenellum* (Smith, 1871) juveniles fed isoproteic diets substituting fish meal by soybean meal. *Brazilian Archives of Biology and Technology* **51**: 61–69.
- Markey J C, Amaya E A and Davis D A. 2011. Plant protein by product proteins tested in shrimp diet. *Global Aquaculture Advocate* (1): 48–49.
- Mohanty S N and Rath S C. 2008. Terrestrial and plant ingredient

- sources accessibility for aquafeed. *Special Symposium on Fish Nutrition* 22–26 Nov. 8th edn. pp. 28–29 Indian Fisheries Forum.
- Muzinic L A, Thompson K R, Morris A, Webster C D, Rouse D B and Manomaitis L. 2004. Partial and total replacement of fish meal with soybean meal and brewer's grains yeast in practical diets for Australian red claw crayfish *Cherax quadricarinatus* *Aquaculture* **230**: 359–76.
- Snedecor G W and Cochran W. 1967. *Statistical Methods*, 6th edn. Oxford and IBH, New Delhi.
- Suárez J A, Gaxiola G, Mendoza R, Cadavid S, Garcia G., Alanis G, Suárez A, Faillace J and Cuzon G. 2009. Substitution of fish meal with plant protein sources and energy budget for white shrimp *Litopenaeus vannamei* (Boone 1931). *Aquaculture* **289**: 118–23.