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Nutritional requirement of fresh water prawn and shrimps: A review

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Abstract
The freshwater prawn and marine shrimps are the most important species cultured all over the world. These species are perking up due to their higher growth efficiency and commercially consumer's preferred species. The main source of nutrients required by these species is almost similar to that of each other. In the nutrient levels check both prawn and shrimp protein requirement level should be more than 30% for their better growth and survival. Like all aquatic animals, prawn and shrimps both require nutritive supplements such as protein (amino acids), lipids (essential fatty acids), energy sources (lipids, protein, and carbohydrates), vitamins and minerals in an optimal level for their daily metabolism. In the acceptable levels nutrients studies are been performed and designed for the feeding purposes. The current review article compiles the levels of nutrient supplements which are recommended in specific to *Macrobrachium rosenbergii* and marine shrimps.

Keywords: *Macrobrachium rosenbergii*, shrimps, nutritive supplements, amino acids

1. Introduction
The world population is growing inevitably to meet the demand for good-quality food; this made to focus on development of aquaculture. The world total aquaculture production in 2015 was 106 million tonnes in live weight with an estimated farm gate value of US$163 billion [15]. This total is comprised of farmed aquatic animals (76.6 million tonnes, US$157.9 billion), aquatic plants (29.4 million tonnes; US$ 4.8 billion) and non-food products (41.1thousand tonnes; US$208.2 million). By this huge production in aquaculture the contribution of fish and shellfish is more [15]. By this expansion in terms of continuous production it reveals that these species has high demand in future.
The fresh water prawn *M. rosenbergii* is native to Indo-West Pacific from northwest India to Vietnam, Philippines, New Guinea and northern Australia [34]. It has been introduced into many countries for aquaculture purposes. The main producer countries of *Penaeus* species are China, Thailand, Indonesia, Brazil, Ecuador, Mexico, Venezuela, Honduras, Guatemala, Nicaragua, Belize, Viet Nam, Malaysia, Tawian, Pacific Islands, Peru, Colombia, Costa Rica, Panama, El Salvador, United States of America and India [14]. These two species are getting popular and production have to be increased by providing additional adequate nutrients in the diet results in good survival and growth of cultured animal hence commercial farming of prawn and shrimp depend on provision of nutritional adequate economically viable artificial feeds [47]. Nutritional requirement of freshwater prawn *M. rosenbergii* is less known than those of marine shrimps. The nutritional requirements of fresh water prawn and shrimp in terms of protein, lipid, carbohydrate, vitamins and minerals have been investigated under controlled and semi controlled culture conditions [27]. The nutritional and feeding studies were mainly performed on larvae and juveniles of prawn and shrimp. This made a call for substitute in the researchers to study the nutritional requirement of fresh water prawn and marine shrimps. The rationale purpose of this article is to review the literature available on studies toward the development of practical diets for prawn and shrimps focusing on the nutrient required by different species qualitatively as well as quantitatively.

2. Nutritional profile of Freshwater prawns
The nutritional requirements of *M. rosenbergii* have not been standardized, however during the last decade's knowledge on the nutrient requirements are being experimentally performed for practical uses. Prawns are capable of digesting a wide range of foods both from plant and animal origin [32].

By this selection of diets are characterized by the activities done by digestive enzymes in the alimentary tract which indicates the presence of trypsin, amino peptidases, proteases, amylases, chitinase, cellulase, esterases and lipases [32].

Some of the cultured species among *Macrobrachium spp.* are summarized in Table 1.

Table 1: Nutrient requirement of Macrobrachium *spp*

Macrobrachium spp.	**Common Name**	**Distrubution**	**Reference**
M. americanum	Cauque river prawn	Western watersheds of the Americas	[15]
M. choprai	Ganges river prawn	Ganges and Brahmaputra river	[15]
M. lar	Monkey river prawn	*East* Africa to the Marquesas Islands	[15]
M. Malcolmsonii	Monsoon river prawn	Bangladesh, India and Pakistan.	[15]
M. rosenbergii	*giant river prawn*	South and Southeast Asian	[15]
M. Vollenhovenii	African river prawn	West Africa, from Senegal to Angola.	[15]

2.1 Protein and amino acids

For the regular metabolism of freshwater prawn protein is the most expensive component in prawn feed since it is involved in improved growth, body repair, formation of body components, production of antibodies, enzymes and hormones. Hence the protein rich source incorporated in the different levels is important in economic farming of *M. rosenbergii*. Therefore, provision of right type and level of protein incorporated in the diet plays a major role in the well-being of prawn. The source of protein should also be considered and amino acid profile of proteins should be similar to that of *M. rosenbergii*

Diets of *M. rosenbergii* which are mainly cultured in clear water systems that do not have any supply of natural foods mean while the protein content should be in the range of 35-40 %, gross energy of 13.37 kJ/g and a protein: energy ratio of 30-31mg protein/kJ is suitable for growth [31]. The optimum protein requirement reviewed by different authors for freshwater prawn is 30 % [17] and Reed and D'Abramo [39] also suggested and estimated the protein requirement of *M. rosenbergii* should be greater than 35 % but less than 38 % in the diet. Many commercial feeds for grow out culture contain 24-32 % crude protein. Sarma and Sahu [43] suggested that diet preparation with a proportion of animal to plant based feedstuffs in the diet of *M. rosenbergii* should be 75:25 and to get a better feed efficiency ratio and growth protein/starch ratio should be1:1 [32].

In the stage of larvae higher protein and lipid requirement are to be provided than the post larvae stages so that highly nutritive *Artemia* nauplii are been practised in the larval diet which contain 55 % protein and 21 % lipid [35]. However, higher protein levels in the diet should be provided for post larvae in first 10 weeks. Therefore *Artemia* nauplii are used in these stages which are normally enriched with highly unsaturated fatty acids and other nutrients. Adjacent to protein supplementation in the diet amino acid requirements of freshwater prawn will be constant during all larval stages and lacking protein can be satisfied by other protein source that resembles the larval amino acid profile. The total amino acid requirement ranges between 13.4–16.6 % and 9.7–11.5 % for glutamic acid and phenylalanine (with cystine) whereas relatively lower amino acid profile was noted in tryptophan (1.4-1.6 %), methionine (1.4–2.7 %) and histidine (2.9-4.2%) [41].

The other diets which are practised in postlarvae stage of prawn are of squid and squilla meal at 14 % which can be resulting in increasing the growth of *M. rosenbergii* [33, 50] reported no detrimental effect on survival, growth rate and PER which were substituted with silk worm pupae for clam meal in semi purified diet for *M. rosenbergii* post larvae. The research which are been performed under laboratory conditions for protein requirement of post larvae and juveniles ranged between 30-45 % [37] and the optimum P/E ratio is reported to be 26-28 mg protein/KJ digestible energy [3]. *M. rosenbergii* brood stock which are reared in ponds mainly rich in natural food (benthic micro and macro fauna) which requires about 30 % protein in the diet and it also requires the same ten essential amino acids as other crustacean [51], but quantitative requirements have not been determined. To optimise the feed formulation and amino acid composition determination of nutrient profile of prawn muscle are be fulfilled [12].

2.2 Carbohydrates

Carbohydrate plays an important role in glycogen storage, chitin synthesis and formation of steroids and fatty acids. Carbohydrates requirement in the diet of *M. rosenbergii* comparatively higher in the specific activity of amylase which is mainly used as a source of energy in larval and post larval [32]. Moreover carbohydrates are the principal substrates in the diet of *M. rosenbergii* which can utilize complex polysaccharides including starch and dextrin than the simple sugars in their metabolism activity. Supplementation of dietary glucosamine facilitates molting in the shellfish followed by enhanced growth parameter [32]. The growth rate of postlarvae can be enhanced by addition of chitin either extracts from the shrimp head meal (natural source) or in purified form intern which enhanced the growth rate. Dietary protein and lipid is optimised at a ratio of 1:2.51: 4 [42].

2.3 Lipids and fatty acids

Fats or lipids are organic molecules containing many carbon atoms in a variety of chains or ring formation. The main function of lipid is high energy storage molecule and a component of cell membrane. The dietary requirement of pawn includes carbohydrate as an energy source; lipid levels in prawn diets can be as low as 5 % as per the analysis quantitative lipid requirements range between 68 % [37; 39]. Mainly pawn require 18:2n6 (linoleic acid) or 18:3n3 (linolenic acid) because they cannot synthesize in their body hence they required in their diet [40]. At optimal dietary levels of 0.075 % are known to increase weight gain and feed efficiency by using n3 and n6 HUFAs remarkably [32]. Approximately 0.30 % of cholesterol should be content in the dietary requirement [42] and there is no need to add high levels of purified cholesterol into freshwater prawn feeds unlike in penaeid shrimp feeds [32]. Although higher levels of lipids and cholesterol are believed to be key factors in egg maturation and egg quality.

A limited ability to biosynthesize phospholipid *de novo* are been reported in freshwater prawn. To meet the demand of *M. rosenbergii* brood stock a basal level of 0.8 % dietary phospholipid is required. Tiwari and Sahu [49] reported that 5 % soyalecithin along with 1 % cod liver oil was effective in promoting growth and survival of *M. rosenbergii.*

2.4 Vitamins

For the normal growth in the fish and shellfish the vitamins are added as organic compounds that are required in small quantities for normal growth [52]. Although vitamins are catalytic in nature; hence they take part in biochemical reaction. Even though studies on qualitative and quantitative requirements are meagre addition of vitamins and mineral supplements are in practice by supplementing in the diets of prawn and shrimps. The *M. rosenbergii* require vitamin ranges between 60-150 mg C/kg diets are probably similar to that of crustaceans. For successful reproduction and larval viability the optimal levels of 60 mg ascorbic acid and 300 mg α tocopherol per kg diet are considered sufficient. Supplementing vitamin C at 240 mg per kg reduces stress in freshwater prawns [28] and the diet contend a level of vitamin E at 200 mg/kg diet modulated some of the antioxidants defence system by decreasing lipid peroxidation in the hepatopancreas [32].

2.5 Minerals

The requirement of minerals in the animals for various life processes including the formation of skeletal tissues, respiration, digestion and osmoregulation. A dietary supplementation of mineral (calcium) in the diet seems to improve growth and very few information are available on the quantitative mineral requirements of freshwater prawn. The improved in performance as been reported in supply (with Ca levels of Ca. 5 ppm) of 3 % calcium in the diet. The optimum dietary zinc level ranges between 50- 90 mg/kg diet [32].

Zimmermanm and New [54] have demonstrated that relationship between dietary calcium level and water hardness which is important criteria for culturing in soft water. Two dietary calcium levels (1.8 and 3.0%) in the diets with Ca: P ratio 1.5: 1 was evaded 1.8% calcium diet performed better well at the highest alkalinity level. High dietary calcium combined with high alkalinity was detrimental to aquatic animals in the culture of freshwater prawn.

Summary of nutrient requirements of freshwater prawn *M. rosenbergii* based on laboratory trials [32] are listed in Table 2.

Table 2: Nutrient requirement of fresh water prawn *M. rosenbergii* [26]

Nutrients	Growth stages	Requirement
Protein (%)	Brood stock	38-40
	Juveniles (2nd 4th month)	35-37
	Adult (5th 6th month)	28-30
Carbohydrate (%)	For all stages	25-35
Lipid, including phospholipids (%)	For all stages	3-7
Highly unsaturated fatty acids (%)		> 0.08
Cholesterol (%)	For all stages	0.5-0.6
Vitamin- C (mg/kg)	Grow out	100
Calcium/Phosphorus		1.5-2.0:1
Zn (mg/kg)		90
Other minerals		Quantitative requirements not yet known
Energy	Broodstock	3.7-4.0 kcal/g feed
	Other stages	2.9-3.2 kcal/g feed

Table 3: Specification for fresh water prawn feeds under legislative in Thailand. (S. Thongrod, pers. Comm. 1999)

Types	Protein (%)	Lipid (%)
Complete feeds		
Larvae(4-15 days)	>37	>5
Juvenils	>30	>4
Juveniles(5-12g)	>25	>3
Large size prawns	>25	>3
Supplementary feed	>20	>3

Table 4: Nutrition requirement of post larvae and broodstock of *M. rosenbergii*

Nutrients	Requirement	Species	Author's
Protein and amino acids	35-40%	*M. rosenbergii*	[4, 25]
Broodstocks			
Broodstocks	30 %	*M. rosenbergii*	[13]
Broodstocks	24-32%	*M. rosenbergii*	[9]
Post larvae and juveniles	30-45 %	*M. rosenbergii*	[36]
Post larvae and on growing	55 %	*M. rosenbergii*	[26]
Vitamin C	240 mg/kg	*M. rosenbergii*	[22]
Vitamin E	200 mg/kg	*M. rosenbergii*	[22]

3. Nutritional profile of Marine shrimps

3.1 Proteins and amino acids

Protein is a key building block for feed formulation systems and a major expensive component of all feed components [44]. The continuous supply of essential amino acids should be supplemented for the maintenance and growth of shrimp. Although the growth involves a mixture of soft and hard tissues for the growth purposes shrimp do not prefer specific type of protein like fishmeal but do require a source of nonspecific nitrogen (dispensable amino acids) and essential

amino acids. Shrimp require 10 essential amino acids (EAA) in their diet such as arginine, methionine, valine, threonine, isoleucine, leucine, lysine, histidine, phenylalanine and tryptophan [16]. Commercial shrimp feed formulation includes generally methionine, lysine and arginine as the first limiting amino acids in the formulation [16]. The minimal amount of dietary protein required for *P. monodon* reviewed by different authors for better growth and survival is about 40 % [1], 36 to 40 % [45] and 35 % [46].

Chuntapa *et al.* [7] opinioned that the best growth rate of shrimp fed with range of 33–44 % protein and an energy content of 223–371 kcal/100 g. AQUACOP [2] reported that 330 kcal/100 g was required for optimal growth of *P. monodon*.

3.2 Lipids (fats, oils)

The supplementation of lipids (triacylglycerols) forms a component of cell membranes and energy reserves, so they are considered to be the most important nutrients for shrimp [16]. Lipids required in the diet of penaeids can be categorized into three classes neutral lipids (including essential fatty acids), sterols and phospholipids [11] and carotenoids [25].The studies on shrimp nutrition requirement noted by several authors opinioned that lipids as an essential fatty acids (EFA) in shrimp synthesizes de novo from acetate on their own for their normal growth [26]. For well-being of *Penaeus monodon* four fatty acids are essential in their diet they are linoleic (18:2n–6, LOA), linolenic (18:3n–3, LNA), eicosapentaenoic (20:5n–3, EPA) and docosa hexaenoic (22:6n–3, DHA) acids in that two n–3 highly unsaturated fatty acids (HUFA) are most important [18]. The performance of shrimp growth depends on the lipid contain incorporated in to the diets contain lipids (oils) of marine rather than vegetable origin [21]. Addition of linoleic (18:2n–6, LOA) and linolenic (18:3n–3, LNA) fatty acids into the diet enhanced growth potential of *P. monodon* [19].

The shrimp fed with 35% protein an energy content of 330 kcal/100 g and a lipid: carbohydrate ratio of 1:4.6 found to be highest growth and survival rates [7]. But by supplementing juvenile *P. monodon* with fatty acids such as arachidonic acid (ARA, 20:4n–6) may not promote growth [29] but addition of arachidonic acid in the diet enhances shrimp survival [53].

For the maturation and reproduction of shrimp the dietary n–3 and n–6 fatty acids in the ratio considered to be important to fatty acid metabolism and lipid nutrition [53]. Millamena [30] noted that reproductive performance of *P. monodon* was best when the fatty acid profile had a high n–3/n–6 ratio. As essential fatty acids are considered to be important in the diet of shrimp the concept of replacing fishmeal and oil with other substitutes are to be considered in fish nutrition.

3.3 Cholesterol

The shrimp in their diet supplemented with cholesterol would be the most expensive as a single ingredient. For the cell membranes cholesterol is a necessary constituent precursor for steroid hormones. In the dietary source of shrimp sterols are essential because it cannot synthesis of its own [36] and cholesterol is nutritionally superior to other sterols [48].

3.4 Phospholipids

Incorporation of phospholipids (lecithin) in to the diet has a better growth promoting effect in shrimp [20]. From the past soya bean meal are the most commercially important source of lecithin [23] which are commonly used in shrimp diets. Supplement phospholipids into the diet improves performance in lipid digestibility and growth performance of juvenile *P. monodon* with vegetable oils as their lipid source at a concentration of 2 % [25].

3.5 Carbohydrates

Cuzon *et al.* [10] reported that the digestibility of carbohydrates in shrimp varied according to flour type, botanical origin of starch and inclusion level. Best results were reported with standard wheat starch and this is commonly the main starch source in shrimp feeds.

3.6 Fibre

Raw materials high in crude fibre create grinding problems and reduce the binding capacity and water stability of the pellets. The pellet water durability (stability) should last for at least two hours when the feed is immersed in water. Commercial diets should have as low as possible crude fibre levels and should not exceed 4.0 % [23].

3.7 Ash and minerals

The “ash content” is a measure of total amount of minerals present within a food, whereas the “mineral content” is a measure of amount of specific inorganic components present within a food, such as Ca, Na, K and Cl. Shrimp can assimilate some of their minerals directly from the water. The mineral requirements of shrimps have not been fully established [22] where as they can absorb calcium and phosphorus from seawater.

Macronutrients for shrimp nutrition are Ca, P, Mg, K, Cl, S and Na, while the micronutrients are Fe, Zn, Cu, Mn, Ni, Co, Mo, Se, Cr, I, Fl, Sn, Si, Va and As [8]. Seven minerals (calcium, copper, magnesium, phosphorus, potassium, selenium and zinc) have been recommended for inclusion in penaeid shrimp diets [13].

3.8 Vitamins

Fifteen vitamins may be required by shrimp, including the water – soluble vitamins thiamin, riboflavin, niacin, vitamin B6, pantothenate, folate, vitamin B12, biotin, choline, myoinositol (inositol) and vitamin C (ascorbic acid) and the fat–soluble vitamins A, D, E and K [9]. *Penaeus monodon* diets deficient in ascorbic acid, biotin, folic acid, niacin, thiamine and alpha–tocopherol resulted in poor appetite and poorer feed conversion efficiency. Diets lacking a specific vitamin resulted in histopathological changes in the digestive gland cells of *P. monodon* [38].

Table 5: Life stages of shrimps and its food habits [5].

Stage of shrimp	Artificial feed Size (µ)	Natural food
Nauplius	-	
Zoea	147	Phytoplankton
Mysis - P_2	<165	Chaetoceros + Rotifer
P_3 - P_7	>165	Brine shrimp + Rotifer
P_7 - P_{20}		Artificial diet only

Table 6: Nutritional requirement of shrimp [6].

Nutrients	Growth stages	Requirement (%)
Protein (%)	Reproductive stage	38-40
	Juvenile	35-37
	Adult	28-30
Carbohydrate (%)	For all stages	25-35
Lipid including phospholipids (%)	For all stages	3-7
HUFA (%)		>0.08
Cholesterol (%)	For all stages	0.5-0.6
Vit.C (mg/kg)	Grow out	100
Calcoum/phosphorus		1.5-2:1
Zn(mg/kg)		90
Other minerals		Not yet known
Energy	Reproductive stage	3.7-4 kcal/g feed
	Other stages	2.9-3.2 kcal/g feed

Table 7: Amino acids profile of *Penaeus monodon* [6]

Amino acids	Requirement(g)
Arginine	9.16
Histidine	1.52
Isoleucine	3.86
Leucine	8.04
Lysine	6.83
Methionine	2.01
Phnylalanine	4.02
Tyrosine	3.05
Valine	3.70

4. Conclusion

In recent years, however, new research on nutritional requirements of *M. rosenbergii* and marine shrimps are been performed in the field of fish nutrition. All this information which are been researched must eventually be adopted toward developing cost-effective diets that contain the appropriate quality and quantity of nutrients that are specific to the needs dictated by the species cultured. The level of nutrients provided with the researcher provided will vary depending on the resident stages and the quantity of biomass in pond culture. However in recent year's nutritional requirement of the species plays a major factor in determining the success or failure of the crop. While the recommended nutritional factors are to be provided to the animals cultured without access to natural biota require nutritionally complete diets.

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