An overview on nutrition and feeding of prawn 
(Penaeus Japonicus)

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ABSTRACT

This paper presents an overview of the biochemical aspects of shellfish nutrition especially that of prawn (Penaeus japonicus). Although the nutritive requirements of the prawn are same as for other animals (adequate levels of protein, lipids, carbohydrates, minerals and vitamins) for their growth. The study with prawn has revealed its unique aspects of metabolism especially lipid metabolism. Based on this biochemical knowledge, various formulations of artificial diets have been used for the mass requirement of different growth stages of P. japonicus.

Key words: Prawn (Penaeus japonicas), Nutrition, Feeding.

INTRODUCTION

Crustacean farming such as that of shrimps and prawn has made significant progress during the last few decades in many parts of the world due to luxuriant profitable commodity. The most favored species were those which commanded the highest prices when sold as luxury foods. Increasing demand and benefits have provided sufficient stimulus to promote investment in prawn culture by the private sector. In order to help and solve the problems of the industry which have arisen due to rapid expansion and growth of their culture, studies are required on management techniques, diseases and feeding, etc.

Like other animals, shellfish (crustacean) require nutrients which can support growth, maintain life and resistance against diseases. These substances include proteins, lipids, carbohydrates, vitamins and minerals. The proteins are primarily necessary for growth and defense while, fats and carbohydrates provide energy. When usual energy furnishing components are not provided in the diet in sufficient amount, the protein is used for heat and energy rather for growth. Vitamins and minerals are important for the regulation of body processes. All these nutrients are interrelated and have to be the part of diets to be fully utilized by the body (Falicitas, 1983; Pascual et al., 1983).

Since Hudinaga (1942) succeeded in rearing the prawn under artificial conditions, technique for rearing from hatching to commercial size have been steadily improved in Japan and have been applied to other penacid species in many countries. Studies on the nutritional requirements of P. japonicus were begun about 40 years ago (Kanazawa et al., 1970; Kitabayashi et al., 1971a). As a result, the specific needs of nutrients for growth and survival of prawn have been identified and developed (New, 1976; 1980).
Compounded artificial diets are presently being used for commercial prawn production. The production of larvae depends primarily on the live feed such as diatoms and Artemia salina L. Production of live feeds requires extensive labour, and facilities that vary with climatic conditions. However, live Artemia nauplii is still considered as one of the best food for rearing of both fish and shellfish larvae. The use of artificial diets can help to reduce feed cost and provide a more consistent nutrition and predictable output (AQUA Culture, 2008). These diets are now successfully used to partially replace live Artemia in commercial shrimp hatcheries. The production of prawns requires knowledge about behavioral, mechanical and physiological processes of feeding at larval or post larval stage. One of the key considerations, in this regard, is the development of the gut structure and its functions. Larvae of crustaceans have a simple gut which gradually becomes complex as the organism grows. The gut physiology and its enzymes also changes during short transit times. The manufacturing of nutritious and easily-digestible diet is still a challenge for nutritionists. This is particularly important in early post larval stages, when the increased consumption of Artemia is becoming a high cost in the hatchery operation. It has been demonstrated with different penaeid species that enzyme secretion is particularly limited in post-larvae, which are unable to digest sufficient amounts of full-length proteins and longer peptides in the feed (AQUA Culture, 2008). As for general nutrition, review had been presented by several other workers (New, 1976; Biddle, 1977; Ceccaldi, 1978; Conklin, 1980; Kanazawa, 1980). Several efforts have been carried out to develop artificial diets capable of sustaining good growth (Das et al., 1996; Venkataramani et al., 2002; Anh et al., 2009). This paper represents an overview of the biochemical aspects of penaeid nutrition, especially prawn larvae and juveniles.

**Micro particulture diets for larval stages of P. japonicas**

Live foods such as diatoms and Artemia salina L. have been used in general for rearing the Zoeal and mysid stages of prawn. Several types of micro particulture diets have been developed and used as live food substitutes for larval prawns (Jones et al., 1979; Villegas & Kanazawa, 1980; Kanazawa et al., 1982). Three approaches for presenting the test diets have been examined: nylon protein micro capsules, carrageenan- microbond and Zein microbond particles. The results demonstrated that all three forms were found to sustain reasonable growth and survival of prawn from the Zoeal to post larval stage when compared to live foods.

**Proteins and amino acid requirements**

Generally speaking, the growth rate of cultured shrimp is highest when the amino-acid composition of their feed is maintained the same as that of their own protein. The amino-acid composition of P. japonicus protein is most similar to that of mollusks such as short necked clam, squid and some small shrimps. The original artificial shrimp feeds include squid meal and short necked clam as an important ingredient, but are very expensive. Therefore, the composition of the artificial feed had to be changed to include cheaper ingredients.

Studies revealed that peptides, as well as free amino-acid, are far inferior to protein as a nitrogen source in the prawn diet. Addition of glycine to the diet significantly stimulated feed intake. It has been concluded that optimum dietary protein level for P. japonicus is within the range of 52 to 57%; this level gave
good results on the basis of weight gain and feed efficiency. The optimum protein level for juveniles ranged from 52% - 57% on the basis of weight gain and feed efficiency (Deshimaru & Youne, 1978a; Boonyaratpalin et al., 1980). In general, juveniles or adult penaeids have been shown to attain optimum growth on diets containing up to 60% protein (New, 1976). Several groups of workers have reported the optimum protein level in diets for Penaeus indicus to be 43% (Colvin, 1976a), Penaeus morden 40% (Aqacop, 1977: Khannapa, 1977), 35% (Bages & Sloane, 1981) and Panaeus setiferus 28% - 32% (Andrews et al., 1972).

Deshimaru & Kuroki (1975) reported that a diet containing crystalline amino acids mixture instead of protein used to study the essential amino acid requirement of prawn and found that such a diet was unsuitable for sustaining growth and survival. Their results indicated that prawn was incapable of efficient utilization of free amino acids in diet. (Kanazawa et al., 1984), therefore, investigated the incorporation of radio active acetate into the individual amino acids of the prawn in order to determine the requirements for essential amino acids. The prawn was shown to require ten amino acids, arginine, methionine, valine, threonine, isoleucine, leucine, lysine, histidine, phenylalanine, and tryptophane. Such amino acids have also been demonstrated to be essential for Penaeus aztecs (Shewbart et al., 1972), P. serratus (Cowey & Forster, 1971, Homarus americanus (Galleghar, 1976), Astacus astecus (Zanee, 1966), Hcrobranchium ohion (Lightner et al., 1977). Teshima (1984) studied the effect of protein levels on growth and survival of prawn larvae with dietary carbohydrate levels but not with dietary lipid levels. The optimum protein levels for prawn larvae were estimated to be around 45% - 55% and 55% or more when the diets contained 25%, 15% and 5% levels of carbohydrates, respectively. The utilization of dietary protein is mainly affected by its amino acid composition, level of protein intake, calorie content of the diet, digestibility of the protein, physiological state of the species, water temperature, and size of prawn (Mukhopadhyay et al., 2003).

Carbohydrate requirements

Carbohydrates are another source of cheap nutrients that play an important role in the growth of prawns. The nutritive value of monosaccharide, especially glucose, for the prawn, P. japonicus, is inferior to that of the disaccharides, sucrose and maltose, and polysaccharides such as starch, dextrin and glycogen. Diets containing glucose or galactose for 30 days resulted high hepatopancreatic glycogen concentration. The serum glucose level of the prawn increases quickly and remains at a high level for 24 hours. Accordingly, the growth of prawn was inhibited with the increased level of dietary glucose. The optimum disaccharides and polysaccharide level in diet was found to be 20% (Boonyaratpalin et al., 1980). Studies revealed that the addition of glucose to diet has inhibited the growth of Pana aztecs (Andrews et al., 1972), P. duoranum (Sick & Andrew, 1973) and P. japonicus (Deshimaru & Yone, 1978b). Abdel Rehman et al. (1979) also demonstrated the addition of over 10% glucose to the diet markedly inhibited growth of prawn. High weight gain has been obtained on diets containing disaccharides (Abdel Rehman et al., 1979). The addition of 0.52% glucosamine to the diet improved growth of prawn but the inclusion of chitin inhibited growth (Kitabayashi et al., 1971a). Pascual et al. (1983) have demonstrated that the addition of sucrose or dextrin as carbohydrate source for
P. monodon juveniles proved better than other carbohydrates. They also pointed out that dietary source of glucosamine is necessary for P. japonicus juveniles which inhibits the growth promoting effect of cholesterol. However, the role of dietary glucosamine is still not clear.

**Lipids and fatty acids requirements**

Fatty acids have been shown to play an important role not only as energy source but also essential nutrients for both fish and crustacean (Teshima, 1978: Yone, 1978). Animals are generally capable of synthesizing steroids but not sterols from acetate (Teshima & Kanazawa, 1971). Crustaceans are capable of converting C28 and C29 sterol to cholesterol (Teshima, 1971) and utilizing ergosterol and Beta-sitosterol to some extent for growth (Kanazawa et al., 1971). Prawns are able to metabolize parent fatty acids such as linoleic and linolenic acids to ω-6 and ω-3 highly polyunsaturated fatty acids (PUFA). Hence, the speed of these reactions appears to be too slow to meet the requirements for essential fatty acids and the ω-3 series of polyunsaturated fatty acid that must be provided in the diet. Thus 20:5 ω-3 and/or 20:6 ω-3 possess higher activity as essential fatty acids in the prawn P. japonicus than 18:2 ω-6 and 18:3 ω-3 (Boonyaratpalin et al., 1980).

Studies revealed that crustaceans as well as fish have a requirement for specific fatty acids (Teshima, 1978) which has also been confirmed by metabolic studies using radioactive traces. Studies on EFA requirements for crustaceans have suggested that the nutritive value of lipids for prawn and shrimps is probably related to the types and contents of EFA. High nutritive values of lipids rich in ω-3 HUFA, such as pollack liver oil and shrimp liver oil have been demonstrated for P. duorarum (Sick & Andrews, 1973). Kanazawa et al. (1977) have pointed out that the superior dietary value was obtained with marine lipids containing ω-3HFA such as pollack liver oil and short necked clam oil, indicating that the inferior dietary value of soya bean oil containing 18: 3 ω-3 is possibly due to the shortage of ω-3 HFAA such as 20: 5 ω-3 and 22:6 ω-3. Guary et al. (1976) also reported a high nutritive value of sardine oil and short neck clam oil for P. Japonicus. Aquacop (1978) reported that cod liver oil resulted in sustained growth and survival of P. merguiensis and was considered one of the best sources of lipid. On the other hand Dashimanu et al. (1979) reported that a good lipid source for P. japonicus diet is a mixture of soybean oil and pollack liver oil (6% in diets 1:3 or 1:1 w/w). Colvin (1976b) also reported that a mixture of wheat germ oil and pea nut oil was best for P. indicus among the vegetable oil. A mixture of pollack liver oil and soybean oil in a ratio ranging from 3:1 to 1:1 containing approximately 1.2–1.8% ω-6 and 0.6–1.2% ω-3 fatty acid in diet is considered to be a desirable dietary lipid source for prawn. According to Boonyaratpalin et al. (1980) the suitable dietary lipid level appears to be approximately 6%. The types and content of EFA dominate the nutritive value of dietary lipids. However, other lipid components such as phospholipids and sterols should be considered in evaluating the dietary value of lipids for prawns and shrimps.

**Phospholipids requirements**

To determine the reason for the superior nutritive value of short necked clam oil (Tapes oil compared with pollack liver oil for the prawn P. japonicus), Kanazawa et al. (1979) examined the effects of several lipid fractions of tapes oil on the
growth of *P. japonicus*. Conklin *et al.* (1980) have shown that the survival rate of juvenile lobsters was remarkably improved by the diet. D’ Abramo *et al.* (1981) pointed out the essentiality of phosphatidylcholin for survival of the juvenile lobster *Homarus americanus*. However, prawns fed on cholesterol-fortified diets attained a remarkably high growth compared to those on non-fortified diets, and it was easily concluded that cholesterol should be included in the diet as an indispensable ingredient. The optimum dietary level was found to be 1.4–2.1%. There is little information available regarding dietary sources of phospholipids that are effective in enhancing or sustaining growth and survival of larval and juvenile *P. japonicus*. Kanazawa (1985) assumed that dietary phospholipids may be required for both the smooth transport of dietary lipids, particularly cholesterol, in the hemolymph and a slow rate of phospholipid biosynthesis.

**Minerals requirements**

Prawn and shrimps may absorb some minerals from the water to some extent. Conklin *et al.* (1975) suggested that the mineralization of shell in juvenile lobsters was improved with calcium rich diets. Deshimaru & Yone (1978c) have shown that *P. japonicus* takes up calcium from seawater and does not require calcium, magnesium and iron. Kanazawa *et al.* (1984) reported that addition of calcium to diets could be necessary to maintain the ratio of Calcium-Phosphorus (1:1) in diets, although growth of *P. japonicus* on diets with and without calcium supplement was compatible. Kitabayashi *et al.* (1971b) have also pointed out the importance of the Ca/P ratio, indicating an optimum ratio of 1:1 for *P. japonicus*. Huner & Colvin (1977) have shown Ca/P ratio of 2.2:1 to the optimum for growth of juvenile shrimp, *P. californiensis*. Shewbart *et al.* (1973) considered that calcium, phosphorus and sodium chloride were not necessary for *P. aztecs*, but phosphorus may be essential. The necessity of phosphorus has been manifested with *P. japonicus* (Kitabashi *et al.*, 1971c; Desimaru & Yone, 1978a; Kanazawa *et al.*, 1982). Deshimaru *et al.* (1979) reported that *P. japonicus* also requires phosphorus (2.0%), potassium (10%) and trace minerals (0.2%). Kanazawa *et al.* (1984) have shown that this species requires Ca (1.0%), P (1.0%), Mg (0.3%), K (0.9%) and Cu (0.8%) in the dry diets. There is some conflict on the published values for the requirement of prawn for Ca and Mg. Since, it is likely that the effect of Ca varies according to types of Ca salt used such as primary, secondary and tertiary salts. The Ca requirement of prawn should be reevaluated by a more detailed experiment. The addition of iron (0.006%) and Mn (0.003%) inhibited growth of *P. japonicus* juveniles. According to Boonyaratpalin *et al.* (1980) supplements of calcium, magnesium, and iron did not improve the nutritive value of the diet at levels of 2%, 0.3%, and 0.02%, respectively. While, supplementary iron rather reduced its value. The improved effect of phosphorus supplementation was noticed at a 2% level in the diet. The group fed on the diet supplemented with potassium at a level of 1% showed higher growth and feed efficiency than those of the group fed on the diet without it. The suitable level of trace minerals in the diet was found to be 0.2% while levels over 0.2% resulted in a lower nutritive value than the diet without the supplement.

**Vitamins requirements**

The effect of vitamins on growth and survival of juvenile lobsters has been demonstrated by Conklin *et al.* (1980) using a purified diet. The vitamin requirement of the juvenile *P. japonicus* have been investigated by Kanazawa *et
al. (1976); Guary et al. (1976) and Deshimaru & Kuroki (1979), (Table I). Kanazawa et al. (1989) had examined the use of carrageenan microbound test diets, the vitamin requirements of \textit{P. japonicus} larvae. These larvae fed on a vitamin free diet did not reach the post-larval stage, suffering 100% mortality in the mysid stage. The survival of prawn larvae was extremely low when they were fed on diets lacking either tocopherol, calciferol, choline and vitamin C. Addition of vitamin C to a squid based diet for Juvenile \textit{P. japonicus} accelerated growth rate, however, excess of vitamin C inhibited growth. Prawn grew best at inclusion levels of 0.22\% (Kitatayashi \textit{et al.}, 1971b). Iwata & Shigeno (1980) reported the whitening induced by vitamin C deficient diets. Lightner \textit{et al.} (1977) have found that \textit{P. californiensis} and \textit{P. stylirostis} sometimes showed an abnormal symptom, named “Black Death” with a characteristic blackening of esophagus wall, cuticle, gastric wall, hind gut wall and gills. “Black death” has been recognized as a symptom of Vitamin C deficiency (Margarelli \textit{et al.}, 1979). The desirable level of dietary thiamine hydrochloride (Vitamin B\textsubscript{1}) was found to be approximately 6 mg per 100 g diet on the basis of growth, or approximately 12 mg based on the thiamine content of prawn at the end of the feeding experiment.

Some problems and diseased symptoms associated with vitamin deficiency as reported by Boonyaratpalin \textit{et al.} (1980) such as retardation of growth and high mortality occurred early on pyridoxine deficient diets. Prawns maintained on a diet with a high pyridoxine level exhibited low growth. The favorable level of dietary pyridoxine was found to be approximately 12 mg per 100 g diet on the basis of both the growth and the pyridoxine content of prawn. The growth and survival of prawn receiving a choline or inositol deficient diet was found to be inferior to those of the complete diet group. The required levels for choline chloride and inositol were estimated to be approximately 60 mg and 200 mg per 100 g of the diet, respectively. Dietary ascorbic acid was found to be effective for the survival, growth and molting of prawn. The requirement for ascorbic acid of prawn was about 500–1000 mg per 100 g of dry diet.

Table 1: Vitamin requirements of \textit{Penaeus japonicus}

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