Biota Vol. 12 (1): 17-22, Februari 2007
ISSN 0853-8670

Protein/Amino Acid and Carbohydrate Requirements of *Penaeid* Prawns

Kebutuhan Protein/Asam Amino dan Karbohidrat Bagi Udang-Udang *Penaeid*: *Suatu Studi Literatur*

Eka Rosyida

Program Studi Budidaya Perairan, Fakultas Pertanian, Universitas Tadulako, Palu

Abstrak

Suatu studi literatur dilakukan untuk menelaah kebutuhan protein/asam amino dan karbohidrat bagi udang-udang *penaeid*, suatu jenis udang yang bernilai ekonomis penting di Indonesia maupun di pasaran dunia. Salah satu hal penting dalam membudidayakan udang tersebut adalah berkaitan dengan kebutuhan nutrisi pada fase larva. Pemberian nutrisi yang buruk dianggap secara langsung maupun tidak langsung dapat menyebabkan timbulnya beberapa penyakit, kematian massal dan penurunan produksi. Kebutuhan protein udang *penaeid* mempunyai korelasi dengan aktivitas enzim proteolitik dan dipengaruhi oleh umur, ukuran dan tahapan/fase dari siklus hidup udang tersebut. Faktor kualitas dan tingkat energi dari sumber protein yang diberikan secara signifikan berpengaruh terhadap pertumbuhan udang, sedangkan disakarida dan polisakarida dianggap lebih efisien sebagai sumber karbohidrat untuk udang *penaeid* dibanding monosakarida.

Kata kunci: udang *penaeid*, larva, enzim proteolitik, protein, karbohidrat

Diterima: 09 Juni 2005, disetujui: 02 Agustus 2006

Introduction

Penaeid prawns are the most important commercially cultured crustaceans throughout the world. These species are highly prized in most markets, especially in Asia. Penaeids that are of economic interest are black tiger, *Penaeus monodon* Fabricius, kuruma prawn, *P. japonicus* Bate, the eastern king prawn, *P. plejebus*, the school prawn, *Metapenaeus macleayi*, brown tiger prawn, *P. esculentus,* and the banana prawn, *P. merguensis* (CSIRO, 2000). In Indonesia, *P. monodon* is an export commodity (Anonymous, 2000), making a high value income for the country. Together with the increased interest in the penaeid prawns commercial cultivation throughout the world, there has been considerable research conducted on these species, but so far the kuruma prawn is the species that has been most thoroughly studied (Shiau, 1998).

The culture techniques of prawns are well developed, however some problems still remain. These problem areas focus on the early prawn stages, which are the most critical stages, and a key problem is that of larval nutrition (O'Sullivan and Thomas, 1994; Anonymous, 2000). Several studies have reported that an inappropriate diet may result in retardation of growth, even increase the incidence of disease and increase overall mortality as a result of substandard nutrition and starvation (Kanazawa, 1984; Liao, 1992; O'Sullivan and Thomas, 1994). Almost half of the reasons of prawn disease tend to be either directly or indirectly related to nutritionally deficient diets (Kanazawa, 1984). In Japan, mass mortality of cultured prawn larvae was most likely caused by poor nutrition that resulted in epizootics disease (Johnston, 2000). Other researchers have observed the Runt Deformity Syndrome (RDS) during the post larval (PL) phase of *P. vanammei* and it is believed that this problem occurs as a result of poor diets (Wyban and Sweeney, 1991). Mass mortality in *P. monodon* ponds in Taiwan that caused a reduction in production of prawns (Liao and Sheen, 1993) is thought to be due to poor nutrition as one of several possible causes.

Penaeid prawn larvae develop in of several stages: nauplii, protozoea, mysis, post larvae (PL) and juvenile (Iversen *et al*., 1993, Johnston, 2000). PL are also called megalopa or early juvenile or 'fry' for commercial purposes (Motoh, 1985). In some studies, "fry" are called 'late PL', while several reviews used only the term "larval prawn" in their studies without going into greater detail (*eg*. Coutteau *et al*., 1997). Therefore, the terms PL and juvenile stage are ambiguous in the literature.

Lack of consistent terminology between stages makes it difficult to determine the prawn's biological needs, in particular the dietary requirements at each stage. Maguire (1980), Liao and Sheen (1993), Shiau, (1998), noted that as penaeid species inhabit different environments, which are associated with different life history phases, these phases are likely to have different dietary requirements. The following review presents the nutritional requirements of penaeid prawns termed either PL or juvenile, focusing on protein/amino acid and carbohydrate requirements.

Protein/amino acid requirements

Protein is an essential component of the diet that plays important roles in living organisms (Kanazawa, 1989, Shiau, 1998, Guillaume e*t al*., 2001). Crustaceans need protein in the form of essential amino acids for maintenance of life, growth, tissue repair and reproduction (Liao and Sheen, 1993; Guillaume, 1997). Consequently, proteins are a major component of feeds and their importance has been demonstrated in some species of prawn (Andrews *et al*., 1972; Alava and Lim, 1983; Bautista, 1986; Ali, 1992; Baillet *et al*., 1997; Guillaume, 1997; Guillaume *et al*., 2001).

Table 1. Protein requirements for various species of penaeid prawn (% dry weight)

***Penaeus* spp.**	**Requirement (%)**	**References**
P. aztecus	40	Venkataramiah *et al*., 1975
	51	Zein-Eldin and Corliss, 1976
P. brasiliensis	55	Liao *et al*., 1986
P. californiensis	35	Colvin and Brand, 1977
P. duorarum	30	Sick and Andrews, 1973
P. indicus	43	Colvin, 1976
	40	Bailly and Cuzon, 1984
P. japonicus	50	Deshimaru and Kuroki, 1975a
	52-57	Deshimaru and Yone, 1978a
	45-55	Teshima and Kanazawa, 1984
P. merguensis	34-42	Sedgwick, 1979
P. monodon	45-50	Lee, 1971
	35-40	Lin *et al*., 1982
	40	Alava and Lim, 1983
	40-50	Bautista, 1986
	40-44	Shiau *et al*., 1991a
	36-40	Shiau and Chou, 1991
P. setiferus	28-32	Andrews *et al.,* 1972
	30	Lee and Lawrence, 1985
P. stylirostris	35	Colvin and Brand, 1977
P. vannamei	30	Colvin and Brand, 1977
	>36	Smith *et al*., 1985
Mean	39.8-45.6	
SD	1.7-2.5	

Compiled from: Chen (1993), Guillaume (1997), Shiau (1998)

In general, the optimum protein requirements of prawns was positively correlated to the proteolytic enzyme activity, and the age or the life cycle stage of prawn influenced these digestive enzyme activities (Chen, 1993). The protease activity increased from zoea to mysis stage and then remained stable throughout the rest of the growth stages. Prawn nutrition studies in Taiwan by Liao and Sheen (1993), however, found that the quality of the protein source may significantly alter protein requirements of juvenile *P. monodon*. They suggested that *P. monodon* required more than 35% protein in the diet and increasing protein levels above 35% did not guarantee improved growth rates. Other authors estimated the optimum protein level of the same species was 45 - 50% if using casein and fish meal as protein source (Lee, 1971, *in*: Liao and Sheen, 1993) or 35% if only white fish meal was used as the source of protein (Lin *et al*., 1981, *in*: Liao and Sheen, 1993). Experiments with juvenile *P. japonicus* have indicated a requirement of 30-60% protein in general (New, 1976) and needed 52-57% protein when using casein (Deshimaru and Yone, 1978) for an optimum growth. A level of 43% protein of a fish meal based diet was recommended for juvenile *P. indicus* (Colvin, 1976 *in* Shiau, 1998), whereas a level of 33% protein in a commercial diet was suggested to satisfy *P. stylirostris* (Baillet *et al*., 1997).

According to Guillaume (1997) protein requirements, to a large extent, were affected by stage and size an animal, protein quality and energy level of the diet. Prawns that weigh less than 1.0 g seem to show greater protein requirements (35 - 55%) than those that weigh above 1.0 g (40% or less) (Chen, 1993; Guillaume, 1997). However, ignoring the protein source and the weight or age, the average reported optimum dietary protein concentration for various penaeid prawn species is 39.8 ± 1.7 (mean ± SD; n=22) to 45.6 ± 2.53 (mean ± SD; n=9) (Table 1).

Other factors, such as temperature and salinity have also influenced the protein requirements of prawns (Guillaume, 1997), although he noted that the optimum level is not dependent upon temperature, but rather correlated to size or age.

It has been shown by Shiau *et al*., (1991) that under different salinities, juvenile *P. monodon* had different optimal dietary protein. They found that juvenile *P. monodon* needed a greater proportion of protein when reared in 16 ppt brackish water (44% protein) than when reared in 32 ppt seawater (40%).

The fundamental stuctural unit of the protein molecule is the amino acid. There are 10 amino acids that are essential for *P. japonicus* (Kanazawa, 1989), *P. aztecus* (Shewbart *et al*., 1972) and *P. monodon* (Coloso and Cruz, 1980): arginine, methionine, valine, threonine, isoleucine, leucine, lysine, histidine, phenylalanine and tryptophan. Protein requirements of crustaceans were influenced by the quality of the essential amino acid profile of the protein, age or physiological state of the prawn (D'Abramo and Sheen, 1994).

A growth response of *P. japonicus* was observed by Kitabayasi *et al*., (1971) when arginine and methionine were added in their diets. In 1994, Liou and Yang were able to show a methionine requirement for juvenile *P. monodon* and estimated the requirement of this essential amino acid was 1.4g/100g diet, while Millamena *et al*., (1996) found that *P. monodon* PL required threonine at 1.4g/100g diet and valine at 3.75g/100g protein.

Carbohydrate requirements

Carbohydrate is usually the cheapest source of energy in the diet of animals, including prawns. Hence, several studies have attempted to increase the percentage of carbohydrate to meet the metabolic energy requirements, so the more expensive protein can be spared for growth.

Research on most penaeid prawn species suggest that disaccharides and polysaccharides are more efficiently utilised as carbohydrate sources than the simple sugars (monosaccharides). A number of studies related to the effects of various types of carbohydrate have identified that the inclusion of glucose in the diets of juvenile *P. japonicus* (Deshimaru and Yone, 1978), *P. monodon* (Alava and Pascual, 1987; Shiau and Peng, 1992) and *P. setiferus* (Andrews *et al.,* 1972;

Sick and Andrews, 1973) showed a reduction in weight gain. The authors also found a low survival rate in the group of prawns fed on the diet containing this monosaccharide. In contrast, prawns maintained on a diet containing disaccharides, such as sucrose (Deshimaru and Yone, 1978) or polysaccharides, i.e starch (Sick and Andrews, 1973; Aquacop, 1978; Shiau and Peng, 1992) exhibited greater weight gain and better survival rates. Other carbohydrate sources, i.e. trehalose and dextrin have also produced a good growth in juvenile *P. monodon* (Shiau and Peng, 1992).

New (1976) concluded that as a carbohydrate source, starch has a high digestibility and is therefore better for prawn diets compared to glucose. Kanazawa (1984) explained that the difficulty in utilising glucose in *P. japonicus* is mainly due to the prawn's inability to convert the dietary glucose to trehalose in the stomach, rather than absorption from the stomach and release into the blood. Thus, a high glucose level in the blood would occur when a large quantity of glucose was absorbed, a process that the hormonal system was unable to control.

Chen (1993) summarised that a relatively high content of carbohydrate in the diet seems suitable for *P. monodon*, both PL and juvenile stages. Even so, the level of dietary carbohydrate required to satisfy penaeid prawns varies depending on species and type of carbohydrate source (Table 2).

Interestingly, some studies have noted that certain dietary carbohydrates could have a protein sparing effect in the diet of some penaeid prawns. By increasing the level of starch from 30 to 40%, Ali (1982) reported greater growth and survival rates for juvenile *P. indicus* even only containing 30% of protein in the diet. This finding is in agreement with Shiau and Peng (1992), who found that juvenile *P. monodon* demonstrated good growth although the protein level in the diet was decreased from 40 to 30%, while the starch level was increased from 20 to 30%.

Some studies were also carried out to replace one source of carbohydrate with others that is believed to have the same dietary quality but at a lower cost. As rice is cheaper than wheat flour in Taiwan, Sheen and Chen (1991) used extruded rice to replace 7.5% of the wheat flour in the diet of *P. monodon* and produced good growth in this species. Similarly, Shiau *et al*., (1991) noted that the grade of wheat flour, either first or second grade, gave no differential growth effect on *P. monodon* juveniles.

Acknowledgement

I wish to thank Dr. Chris Carter, Dr. John Purser, Dr. Danielle Johnston and Dr. Peter F. Thompson at The University of Tasmania as Reviewers of most of this work.

Table 2. The favorable sources and recommended levels of dietary carbohydrate for various penaeid species (dry matter basis)

Species	source	level in diets	reference
P. japonicus	glucosamine	0.8 %	Kanazawa, 1984
	sucrose	10 %	Deshimaru and Yone, 1978
	starch	10 %	Deshimaru and Yone, 1978
P. monodon	sucrose	17.6 %	Alava and Pascual, 1987
	cornstarch	30 %	Shiau and Peng, 1992
P. indicus	starch	40 %	Ali, 1982
P. duorarum	starch	40 %	Sick and Andrews, 1973
	trehalose	20 %	Alava and Pascual, 1987
	glucosamine	0.52 %	Kitabayashi, *et al*.,1971

References

Alava, V.R. and Lim, C. 1983. The quantitative dietary protein requirements of *Penaeus monodon* juveniles in a controlled environment. *Aquacultur*e 30: 53-61.

Alava, V.R. and Pascual, F.P. 1987. Carbohydrate requirements of *Penaeus monodon* (Fabricius) juveniles. *Aquaculture* 61: 211-217.

Ali, S.A. 1982. Effect of carbohydrate (starch) level in purified diet on the growth of *Penaeus indicus*. *Indian J. Fish*. 29 (1&2): 201-208.

Ali, S.A. 1992. Evaluation of some animal and plant protein sources in the diet of the shrimp *Penaeus indicus*. *Asian Fish. Sci*. 5: 277-289.

Andrews, J.W., Sick, L.V. and Baptist, G.J. 1972. The influence of dietary protein and energy levels on growth and survival of *penaeid* shrimp. *Aquaculture* 1: 341-347.

Anonymous. 2000. Laporan Tahunan 1999/2000.Pusat Penelitian dan Pengembangan Perikanan, Badan Penelitian dan Pengembangan Pertanian, Departemen Pertanian. Jakarta.

AQUACOP. 1978. Study of nutritional requirements and growth of *Penaeus merguensis* in tanks by means of purified and artificial diets. *Proc. World Mar. Soc*. 9: 225-234.

Baillet, C., Cuzon, G., Cousin, M. and Kerleguer, C. 1997. Effect of dietary protein levels on growth of *Penaeus stylirostris* juveniles. *Aquacult. Nutr*. 3: 49-53.

Bautista, M.N. 1986. The response of *Penaeus monodon* juveniles to varying protein/energy ratios in test diets. *Aquaculture* 53: 229-242.

Chen, H.Y. 1993. Recent advances in nutrition of *Penaeus monodon*. *J.World Aqua*. *Soc*. 24(2): 231-239.

Colozo, R. and Cruz, L.J. 1980. Preliminary studies in some aspects of amino acid biosynthesis in juvenile *Penaeus monodon* Fabricius: I. Incorporation of ^{14}C from (U-^{14}C) acetate into amino acids of precipitable proteins. *Bull. Phil. Biochem. Soc.* 8: 821-840.

Coutteau, P., Geurden, I., Camara, M.R., Bergot, P. and Sorgeloos, P. 1997. Review on the dietary effects of phospholipids in fish and crustacean larviculture. *Aquaculture* 155: 153-168.

CSIRO, 2000. CSIRO aquaculture information. CSIRO Marine Research, NSW Fisheries, Australia (Abstract only).

D'Abramo, L.R. and Sheen, S.S. 1994. Nutritional requirements, feed formulation and feeding practices for intensive culture of the freshwater prawn, *Macrobrachium rosenbergii*. *Rev. Fish. Sci*. 2(1): 1-21.

Deshimaru, O. and Yone, Y. 1978. Effect of dietary carbohydrate source in the growth and feed efficiency of prawn. *Bull. Jpn. Soc. Sci. Fish*. 44 (10): 1161-1163.

Guillaume, J. 1997. Protein and Amino Acids. In: D'abramo, L.R., Conklin, D.E., Akiyama, D.M. (Eds.). *Crustacean Nutrition* 6: 26-50. World Aquaculture Society, Baton Rouge, Louisiana.

Guillaume, J., Kaushik, S., Bergot, P. and Metailler, R. 2001. *Nutrition and Feeding of Fish and Crustaceans*. The Bookshope, India. 432 pp

Iversen, E.S., Allen, D.M. and Higman, J.B. 1993. *Shrimp capture and culture fisheries of the United States*. Fishing News Books, Cambridge. 247 pp.

Johnston, D. 2000. *An Outline for Intensive Crustacean Culture Unit.* School of Aquaculture,The University of Tasmania, Australia.

Kanazawa, A. 1984. *Nutritional requirements and artificial diets of Kuruma shrimp*, *Penaeus japonicus*. In: Sindermann, C.J. (Ed.). Proceedings of the 9th and 10th US-Japan meetings on aquaculture. pp. 3-7.

Kanazawa, A. 1989. Protein requirements of penaeid shrimp. Advances in tropical aquaculture. AQUACOP IFREMER. *Actes de collogue* 9: 261-270.

Kitabayashi, K., Kurata, H., Shudo, K., Nakamura, K. and Ishikawa, S. 1971. Studies on formula feed for kuruma prawn: I. On the relationship among glucosamine, phosphorus and calcium. *Bull. Tokai Reg. Fish. Res. Lab*. 65: 91-107.

Liao, I.C. 1992. *Penaeid* larviculture: Taiwanese method. In: Fast, A.W., Lester, L.J. (Eds.), *Marine shrimp culture: principles and practices*. pp. 193-214. Elsevier, Amsterdam.

Liao, I.C. and Sheen, S.S. 1993. Prawn nutrition studies in Taiwan. In: Mc.Vey, J.P. (Ed.). *CRC handbook of mariculture 2nd edition Vol.1, Crustacean Aqua*culture. pp. 95-103. CRC Press, Boca Raton.

Liou, C.H. and Yang, S.D. 1994. Dietary methionine requirements of *Penaeus monodon*. A paper presented at the annual meeting of Taiwan Fisheries Society. Dec.5-8, Taipei, Taiwan.

Maguire, G.B. 1980. *A review of the farming and biology of penaeid prawns with emphasis on juvenile scholl prawns (Metapenaeus macleayi*). New South Wales State Fisheries.80 pp.

Millamena, O.M., Bautista, M.N. and Kanazawa, A. 1996. Valine requirement of postlarval tiger shrimp *Penaeus monodon*. *Aquacult. Nutr*. 2 (3): 129-132.

Motoh, H. 1985. *Biology and ecology of Penaeus monodon*. In: Taki, Y., Primavera, J.H., Leobrera, J.A. (Eds.). Proceedings of the First International Conference on the Culture of the penaeid prawns/ shrimps, Iloilo City, Philippines, 1984. pp. 27-36.

New, M.B. 1976. A review of shrimp and prawn nutrition. *Proc. World Mar. Soc*. 7: 277-287.

O'Sullivan, D. and Thomas, P. 1994. *Improving the productivity of prawn ponds*: a prawn farming manual for Australian growers. Turtle Press, Tasmania. 62 pp.

Sheen, S.S. and Chen, J.C. 1991. The feasibility of extruded rice in shrimp feed to replace wheat flour for tiger prawn, *Penaeus monodon*. 22nd Annual Meeting of the World Aquaculture Society, World Aquaculture Society, Baton Rouge, LA. (Abstract).

Shewbart, K.L., Mies, W.L. and Ludwig, P.D. 1972. Identification and quantitative analysis of the amino acids present in protein of the brown shrimp, *Penaeus aztecus*. *Mar. Biol*. 16: 64-67.

Shiau, S.Y. 1998. Nutrient requirements of *penaeid* shrimps. *Aquaculture* 164: 77-93.

Shiau, S.Y., Lin, S.F. and Lu, L.J. 1991. Effects of different types of wheat flour in feed for grass prawn, *Penaeus monodon*. *Nippon Suisan Gakkaishi* 57 (4): 705-710.

Shiau, S.Y. and Peng, C.Y. 1992. Utilization of different dietary protein levels in Grass prawn, *Penaeus monodon*, reared in seawater. *Aquaculture* 101: 241-250.

Sick, L.V. and Andrews, J.W. 1973. The effect of selected dietary lipids, carbohydrates and proteins on the growth, survival and body composition of *Penaeus duorarum*. *Proc. World. Mar. Soc*. 4: 263-276.

Wyban, J.A. and Sweeney, J.N. 1991. *Intensive shrimp production technology*. The Oceanic Institute, Honolulu, Hawaii.158 pp.