Asian Fisheries Science **16** (2003): 25-31
Asian Fisheries Society, Manila, Philippines

Biochemical Constituents of Shrimps from Semi-Intensive and Modified-Extensive Culture Ponds

P. JANAKIRAM, L. JAYASREE, and R. MADHAVI*

Department of Zoology,
Andhra University,
Visakhapatnam - 530 003
India.

Abstract

A quantitative study on the occurrence of major biochemical constituents including protein, carbohydrate, lipid and cholesterol in the muscle of different growth stages of *Penaeus monodon* collected from semi-intensive (SI) and modified-extensive (ME) culture ponds of coastal Andhra Pradesh, adopting different feeding schedules was undertaken. The objective was to determine the effects of the age of shrimp and the stocking density on the biochemical composition of the muscle. Protein was found to be the major biochemical constituent and an increase in protein content with advancement of shrimp age was recorded. Glycogen occurred only in traces. Lipid and cholesterol occurred in moderate quantities with concentrations slightly higher in shrimps of SI ponds as compared to those of ME ponds. Overall, the stocking density had little impact on protein and glycogen concentration in the muscle.

Introduction

Brackishwater shrimp culture involving *Penaeus monodon* has developed as a major industry in India, where three types of culture activities were designated, based on differences in stocking density namely; extensive, modified-extensive and semi-intensive, are in practice. Associated with differences in stocking densities, wide variations exist in the management of the three types of culture activities especially in the quantity of artificial feed used as input. In the extensive culture, the shrimps depend mostly on natural food items available in the pond, in the case of semi-intensive and modified-extensive culture, the natural diet is to be supplemented with large quantities of artificial feed; the constituents of which include proteins, carbohydrates, fats, vitamins, minerals and others. It is to be expected therefore, that differences in the diet of shrimps from different categories of ponds, would be reflected in the biochemical composition of the muscle, which in turn determines the nutritional quality (dietary) of shrimp muscle.

**Corresponding author*

Very little information as yet is available on the quantitative occurrence of major biochemical constituents in the shrimps and information available in this direction has been restricted to shrimps of wild origin (Shaikmahmud and Magar 1957 and 1961, Sriraman and Reddy 1977, Achutankutty and Parulekar 1984, Ramraj and Kalaimani 1993), while those from culture ponds have received little attention.

Along the coast of North Andhra, the culture activity of tiger shrimp, *P. monodon* involves both modified-extensive and semi-intensive types. An investigation on the biochemical composition of shrimps of different ages collected from the two categories of culture system was undertaken during the period April 1996 to August 1996, which covers one crop cycle. This paper deals with changes in the quantitative occurrence of protein, carbohydrate, lipid and cholesterol content in the muscle of shrimps with reference to shrimp age and type of culture activity i.e., modified-extensive or semi-intensive.

Materials and Methods

Individuals of *P. monodon* were collected during the period April to July 1996, from eight culture ponds selected from two farms belonging to modified-extensive and semi-intensive categories, located at Mulakuddu (Visakhapatnam district) and Kakinada (East Godavari district) respectively. For convenience, the modified-extensive ponds are designated here as ME_1, ME_2, ME_3, ME_4 and the semi-intensive type as SI_A, SI_B, SI_C, SI_D. The shrimp samples consisting of a minimum of 4 individuals from each pond were collected at fortnightly intervals commencing from 30 days post-stocking, and carried to the laboratory in live condition, in polythene bags. After noting the size and weight, they were sacrificed and muscle tissue was analyzed for protein, glycogen, lipid and cholesterol content by adopting standard methods (Association of Agricultural Chemists, Washington, 1980). Total protein and glycogen were estimated from fresh muscle tissue using Folin-Phenol and Anthrone methods respectively. Lipid and cholesterol, were estimated respectively by employing phosphovanilin and $Fecl_3$-H_2S0_4 methods. The results are expressed as percent muscle tissue.

The data collected were analyzed to determine the effects of age as well as the impact of stocking density on the quantitative distribution of major biochemical constituents in shrimp muscle. ANOVA and Student's t-tests were employed to determine the significance of differences noted in the occurrence of various biochemical constituents in the shrimps, a) from the two different farms b) from different ponds within a farm and c) of different ages.

Results and Discussion

Pond characteristics

Characteristics of the eight ponds selected for the study, including information on stocking densities, survival rates, feeding regime and biomass production are shown in table 1. Briefly, stocking densities ranged from 3 to 4/m^2 in ME ponds and 15 to 20/m^2 in SI ponds. Accordingly the quantity of feed utilized was higher in SI ponds (1636 to 5505 kg, FCR : 1.3 to 3.8) as compared to ME ponds (816 to 1370 kg, FCR: 1.3 to 2.9). Locally available commercial (CP brand) feed was used in both ME and SI ponds and the composition of the feed is shown in table 2. Pond management procedures were also different for the two types of farms, the inputs in the form of fertilizers being very high in SI ponds.

Data on the quantitative distribution of protein, glycogen, lipid and cholesterol in the muscle of shrimps of different ages collected from the 8 selected ponds, are shown in tables 3 to 5.

Table 1. Details of stocking densities, water exchange rates, fertilization, FCR, survival and growth in ME and SI ponds

Ponds	ME_1	ME_2	ME_3	ME_4	SI_A	SI_B	SI_C	SI_D
Area (ha)	1.3	0.8	1.0	0.4	1	0.55	0.6	1
Total biomass obtained (kg)	650	900	912	274.8	2575	424.6	949.8	2225
Biomass (Kg·ha)	500	1125	912	687	2575	772	1583	2225
Stocking density (individuals·m^2)	3	3.5	5.4	3.75	15	20	20	15
Production (kg·ha·day)	3.7	8.85	6.37	4.6	17.4	6.44	13.2	15.6
Water exchange (%)per week	13	16	15	14	19	26	20	24
Culture period (days)	135	125	143	150	148	120	120	142
Survival(%)	56	88	71	43	46.5	12.3	25.6	42
Total feed used (kg)	887	1200	1370	816	5055	1636	2183	5505
Feed used in kg·kg of biomass (FCR)	1.36	1.33	1.5	2.96	1.96	3.8	2.29	2.39
Average growth per week (g)	2.349	2.04	1.98	1.91	1.98	2.4	2.03	1.55
Length of prawn at harvest (cm)	14.8	14.8	15.8	18	16.5	15.2	15.0	15.4
Weight (g) at harvest	29	29.1	36.4	42	38	32	29.5	20
Cao (kg)	-	-	-	-	3000	450	240	3300
$Caco_3$ (kg)	-	-	-	-	1520	920	800	720
Urea (kg)	20	25	35	11	64	42	56	28
Superphosphate (kg)	25	20	25	15	16.5	12	10	15
Dolomite (kg)	290	125	150	150	1000	410	510	1230
Lime (kg)	150	150	200	100	-	-	-	-
Zeolite (kg)	50	-	-	2.5	125	75	75	75
Planktamin (kg)	-	-	-	-	1	1	1	1
$KMnO_4$ (kg)	-	-	-	-	-	-	-	10
Vitamin C (kg)	-	-	-		0.3	0.08	0.09	0.38
Malachite green (kg)	-	-	-	-	0.2	-	-	1.2
Probiotics (kg)					43.5	15	12	50

Protein

The study revealed protein to be the most dominant biochemical constituent in all the growth stages of shrimps collected from different ponds in the two farms, contributing to 7.13% to 17.07% of wet weight (table 3).

In all the ponds a gradual increase in protein concentration with an increase in age of shrimp was observed, indicating a positive correlation between the two variables (r = 0.71). Protein concentration varied from 7.13 to 16.31%

Table 2. Composition of the commercial feed (CP Brand) used for shrimps in the selected culture ponds

Constituents (%)	Feed 1	Feed 2	Feed 3	Feed 4	Feed 5	Feed 6
Protein	42	41	40-41	40-41	39	38
Fat	5	5	5	5	5	5
Ash	16	16	16	16	16	16
Fibre	3	3	3	3	3	3
Miosture	11	11	11	11	11	11

Table 3. Percent protein concentration in the muscle of shrimps of different ages from ME and SI ponds

	Percent Concentration of Protein							
	ME Ponds				SI Ponds			
Age of shrimp (days)	ME_1	ME_2	ME_3	ME_4	SI_A	SI_B	SI_C	SI_D
30	8.1	7.13	7.2	9.27	7.6	10.18	9.28	8.02
45	9.0	7.33	8.9	9.0	7.91	8.86	9.18	7.97
60	9.7	7.9	8.24	10.19	8.3	9.54	9.53	9.51
75	9.59	8.54	9.2	11.57	8.36	9.64	8.95	8.59
90	11.65	9.6	10.98	12.57	9.65	9.6	8.39	8.21
105	15.6	9.14	11.14	13.05	11.3	11.56	7.39	9.16
120		9.98	11.39	12.64	13.89	11.75	10.74	9.41
135		11.28	9.85	14.1	16.4			11.81
150			11.73	15.24	17.07			13.61
165				16.31				

Table 4. Percent glycogen concentration in the muscle of shrimps of different ages from ME and SI ponds

	Percent Concentration of Glycogen							
	ME Ponds				SI Ponds			
Age (in days)	ME_1	ME_2	ME_3	ME_4	SI_A	SI_B	SI_C	SI_D
30	0.04	0.022	0.04	0.052	0.027	0.12	0.09	0.11
45	0.04	0.024	0.04	0.04	0.048	0.15	0.09	0.11
60	0.0308	0.033	0.045	0.03	0.054	0.21	0.10	0.21
75	0.03	0.057	0.053	0.042	0.03	0.29	0.12	0.18
90	0.043	0.027	0.051	0.08	0.03	0.31	0.1	0.16
105	0.05	0.021	0.049	0.078	0.034	0.21	0.12	0.20
120		0.02	0.053	0.02	0.03	0.24	0.1	0.15
135		0.042	0.04	0.08	0.03			0.14
150			0.058	0.05	0.03			0.14
165				0.03				

in shrimps from ME ponds and from 7.6 to 17.07% in shrimps from SI ponds, the differences noted between the two farms and between the different ponds within a farm were not significant (ANOVA, $F = 2.21$, $P > 0.05$).

The study thus revealed that despite marked differences in density of the stock and the quantity of feed used, no significant differences occur in the protein concentration of shrimps from ME and SI farms.

Earlier studies also reported protein to be the dominant biochemical constituent in the shrimp muscle (Shaikmahmud and Magar 1957,1961, Dabrowsky et al. 1969, Pillay and Nayar 1973, Sriraman and Reddy 1977). Further, in accordance with the results of the present study, Shaikmahmud and Magar (1957) observed an increase in protein content, with increase in age, and presumed it to be the result of accumulation and storage. The present material was sampled from a culture system where shrimps were given considerably large quantities of feed as they grew in size. This increased feeding intensity as shrimp age advances is probably reflected in the higher protein concentration noted in larger shrimps. Achutankutty and Parulekar (1984) however, observed higher concentration of protein in juveniles than in adults, but this was based on shrimps collected from wild.

Glycogen

The glycogen content in the muscle of shrimps was very low in all the ponds and its percentage ranged from 0.02 to 0.08 (Table 4). In two ponds (MI_B and MI_C), a positive correlation occurred between shrimp age and glycogen

Table 5. Percent concentration of lipid and cholesterol in the muscle of shrimps of different ages from ME and SI ponds

Age (Days)	Percent Concentration of Lipid and Cholesterol															
	Lipid								Cholesterol							
	ME Ponds				SI Ponds				ME Ponds				SI Ponds			
	ME_1	ME_2	ME_3	ME_4	SI_A	SI_B	SI_C	SI_D	ME_1	ME_2	ME_3	ME_4	SI_A	SI_B	SI_C	SI_D
30	1.1	1.1	1.2	0.9	2	2.1	2.93	1.4	0.23	0.26	0.26	0.23	0.45	0.82	0.39	0.29
45	1.14	1.19	1.31	0.98	4.01	2.55	3.16	2.8	0.31	0.57	0.33	0.25	0.93	0.79	0.33	0.44
60	0.94	1.27	1.36	0.94	5.48	2.4	3.60	2.44	0.27	0.82	0.37	0.29	1.18	0.76	0.24	0.31
75	0.87	1.16	1.27	1.04	3.8	4.46	3.43	3.56	0.19	0.41	0.32	0.28	0.57	1.13	0.29	0.73
90	0.31	1.21	1.1	1.33	4.21	NA	2.64	4.15	0.12	0.86	0.29	0.21	0.86	1.39	0.46	1.05
105	0.42	1.27	1.98	1.0	2.96	NA	2.4	2.95	0.1	0.32	0.33	0.23	0.79	1.18	0.39	0.86
120		1.29	0.79	0.28	2.39	NA	2.4	1.7		0.23	0.5	0.25	0.68	1.1	0.52	0.45
135		1.0	0.3	0.26	2.56			1.32		0.18	0.23	0.20	0.66			0.34
150			0.39	0.78	2.8			1.2			0.27	0.22	0.71			0.31
165				1.27								0.24				

NA = Not analyzed

content. But no such correlation was noted in other ponds. Achutankutty and Parulekar (1984) also recorded low glycogen concentration in the muscle of penaeid shrimps.

Lipids

The quantity of lipid in the shrimp muscle was found to be higher than that of glycogen but lower than the protein content. The data further revealed that its quantity is significantly higher in shrimps from SI ponds as compared to those from ME ponds (Table 5) ($P>0.05$). Maximum lipid content of 4.46% of wet weight was observed in shrimps of SI_B pond and minimum of 0.26% was recorded from ME_4 ponds. An increase in lipid content with increase in age of shrimps was found in all ponds, initially up to 90 days post-stocking, but thereafter a gradual decline is noted.

Two way ANOVA revealed the differences in lipid concentration in shrimps sampled from the two types of farms to be highly significant ($P>0.05$) but between ponds within a farm, the differences found were not significant ($P<0.05$).

Overall, the total lipid levels were similar to those reported for other penaeids (Guary et al. 1974, Gopakumar and Nair 1975, Chanmugan et al. 1983).

Cholesterol

A positive correlation was observed between cholesterol and lipid contents in the muscle of shrimps from both the farms (SI and ME), although the percentage values for both the constituents varied from pond to pond (Table 5). Maximum cholesterol content was observed in shrimps sampled from ME_2 and minimum in ME_1 ponds. In the case of SI farm, maximum was noted in SI_B and minimum in SI_C. ANOVA revealed difference in the cholesterol content in shrimps from different farms to be significant ($P<0.05$).

The higher values of lipid and cholesterol noted in SI ponds as compared to ME ponds could be related to higher densities in the SI ponds which may result in greater metabolic activity and accumulation of lipid in the muscle.

From the present study, it became evident that stocking density has no influence, whatsoever on the glycogen and protein content of the shrimps. Only lipids were found to occur with a higher concentration in shrimps from SI ponds, which seemed to be caused by dependence on large quantities of artificial feeds.

Acknowledgments

The authors wish to thank the aqua farmers, Mr. A. Prabhakar Reddy and Mr. Vasantha Rayudu, for providing the samples from their shrimp farms. The financial assistance for this work provided by UGC and CSIR, New Delhi is also gratefully acknowledged.

References

Achuthankutty, C.T and A.H. Parulekar. 1984. Biochemical composition of muscle tissue of penaeid prawns. Mahasagar Bull., Natl. Inst. Oceanogr. 17: 239-242.

AOAC, 1980. Official methods of analysis, 13^{th} Edn. (Horwitz, W., ed.,) P. 32 Association of official Agricultural Chemists, Washington.

Chanmugan, P., J. Donovan, , C.J. Whheler and D.H. Hwang. 1983. Differences in the lipid composition of freshwater prawn (*Macrobrachium rosenbergii*) and marine shrimp. Food Sci., 48: 1440-1442.

Dabrowski, T., T.E. Kolakowski and B. Karnica. 1969. Chemical composition of shrimp flesh (*Parapeneaus* spp.) and its nutritive value J. Fish Res. Board Can 26., 2969-2974.

Gopakumar, K and M.R. Nair. 1975. Lipid composition of five species of Indian prawn. J. Sci. Food and Agric., 26: 319-325.

Guary, J.C., M. Kayama and Y. Murakami. 1974. Lipid class distribution and fattyacid composition of prawn *Penaeus japonicus* Bate. Bull. Jpn. Soc. Sci. Fish., 40: 1027-1032.

Pillay, K.K and N.B. Nair. 1973. Observations on the biochemical changes in gonads and other organs of *Uca annulipes*, *Portunus pelagicus* and *Metapenaeus affinis* (Decapoda: Crustacea) during reproductive cycle Mar. Biol., 18: 167-198.

Ramraj, D and N. Kalaimani. 1993. Studies on the quality of brackishwater cultured and wild marine prawn, *Penaeus indicus*. CMFRI, Spl. Publ. 54: 28-32.

Shaikhmahmud, F and N.G. Magar. 1957. Studies in nutritive value of Bombay prawns. Part I. Chemical composition of prawns. J. Sci. Indust. Res., 16A: 44-46.

Shaikhmahmud, F.S and N.G. Magar. 1961. Studies in nutritive value of Bombay prawns, Part II. Chemical composition and nutritional constituents of penaeid prawns. J. Sci. Indust. Res., 20D: 157-158.

Sriraman, K and P.S. Reddy. 1977. Biochemical studies in planktonic juveniles and adults of *Penaeus indicus* and *Penaeus monodon*. Proceedings of the symposium on Warm Water Zooplankton Special Publication. NIO UNESCO 693-699.

Manuscript received 2 December 2000; Accepted 12 October 2002