# Studies on Synthesis And Nutritional Evaluation of Prawn Feeds

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# CERTIFICATE

This is to certify that this thesis is a bonafide record of research carried out by Smt.Ushakumari B under my guidence, in partial fulfilment of the requirements for the degree of **Philosophiae Doctor** of the Cochin University of Science and Technology.

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# D E C L A R A T I O N

I hereby declare that this thesis entitled, **"Studies on Synthesis and Nutritional Evaluation of Prawn Feeds"** is an authentic record of the research carried out by me under the supervision of Dr.N.Chandramohana Kumar, Senior Lecturer, Chemical Oceanography Division, School of Marine Sciences, Cochin University of Science and Technology, and that no part of it has previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar title or recognition.

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# PREFACE

With the advent of the Green Revolution and the Blue Revolution, the average individual has become aware of the need to add quality protein to his normal food intake. In meeting the nutritional requirements of the growing population, the production of high quality fish protein has a vital role and aquaculture has emerged as a major frontier of fish production in the developing countries. Aquaculture refers to the production of aquatic animals and plants such as fishes, shrimps, molluscs and seaweeds in water. Aquaculture can provide the social and economic support to societal needs only if sufficient attention is given with a multi-disciplinary systems oriented approach involving engineers, geneticists, nutritionists, chemists, botanists and microbiologists, along with fishery biologists.

India possess a vast resource with favorable climate and environmental conditions for raising fish production through aquaculture. The potential areas which are suitable water bodies(brackish water) for aquaculture in India estimates to 1.456 million ha of which an area of only about 50,000 ha is presently used for culture, mostly by traditional methods. For an optimum economic production, a concerted effect with the application of modern technologies in the seed, feed and water quality are essential. In fact, systematic feeding fish has been a recent practice in many countries. The problem of feed continues to haunt the prawn culture industry in India. The feed conversion ratio varies according to the nutritional value of the feed to the species. The most efficient FCR, close to 1:1, can be achieved only with quality raw materials, scientific formulations with a balance of nutrients, fortification with vitamins and minerals and proper processing for form, quality and water stability of pellets.

The present work represents an earnest effort in the formulation of cost effective prawn feeds from naturally occurring and easily available raw materials of animal and plant origin. The testing and evaluation of the nutritional quality of the developed feeds with three of the most common species of prawns in this area were also carried out.

The work embodied in the thesis is under publication/under preparation as indicated below.

1. Studies on the role of Tapioca flour as a binder in prawn feeds. Usha Kumari, B. and Chandramohanakumar, N., Aquaculture.

2. Growth response of penaeid prawns to pelleted diets. Usha Kumari, B. and Chandramohanakumar, N., Aquaculture.

3. Effect of P/E on the growth response of penaeid prawns. Usha Kumari, B. and Chandramohanakumar, N., Indian J. Mar. Sci.

4. Preliminary Studies on prawn feeds Usha Kumari, B. and Chandramohanakumar, N., Indian J. Mar. Sci.

5. Effect of protein to carbohydrate ratio on growth response and production of penaeid prawns. Usha Kumari, B. and Chandramohanakumar, N., Mar.Biol.

# CONTENTS

# Chapter I

# INTRODUCTION

The global attention is now directed at the sustainable development in all fields and the strategy for sustainable living titled "Caring for the Earth" prepared by IUCN, UNEP and WWF defines the sustainable development as "improving the quality of human life while living within the carrying capacity of supporting ecosystems". The carrying capacity, a dynamic concept, imply in operational items, the conservation of natural ecosystems as well as their continuous improvement through research, training, technology, community cooperation and public policies. A significant global development in the recent years, at the same time, is the increase in the prices of food commodities thrusting half of the world's population to insufficient and nutritionally imbalance diet. The Sustainable Nutrition Security is defined as "providing physical and economic access to balanced diets and safe drinking water to all people at all times". The attainment of this condition warrants the effective development of aquaculture, as the fishmeal represents a quality protein rich diet and as the production potential per unit area per unit time will be at any time greater than many of the major agricultural crops like cereals.

The nutritional value of fish protein is very high since it contains proportionally larger amounts of lysin and methionine, the two amino acids which are deficient in the main cereal diets of the poor section of the population (Nair *et al.*, 1985). The epidemiological studies indicate that persons consuming diets rich in fish have better cardiovascular health than those consuming meats and the other animal foods rich in saturated fatty acids The high content of the poly-unsaturated fatty acids of n-3 type within some fish oils leads to a plasma triglyceride and cholesterol lowering effect (Sankar *et al.*,1989).

**1.1. Aquaculture.**

The technological developments have helped in opening new vistas to increase fish production in near shore waters from the offshore areas and the open oceans, river valley systems, village ponds, reservoirs and coastal and island saline soils. The high demands for shrimp in the world markets and the inability of natural fisheries to meet the demand have created a world wide interest in their culture during the last decade. The technological input through high quality feed, hatcheries and processing units have given a clear edge over the capital intensive but uncertain marine investing.

In the traditional farming practices post larval and juveniles of fishes and prawns coming through the tidal activity were trapped in adjoining ponds, allowed to grow on natural feeds and periodically harvested. The production in this system was considerably poor.

The aqua production is a three dimensional one and the factors involved in this can be grouped into three categories (i) water quality (ii) seed and (iii) feeding characteristics.

The management of water quality is very critical in aquaculture. The physical, chemical and biological factors, which determine the fertility of water, influence survival, growth, health and production of fish. Processes to modify the environment of the water base, inputs such as liming for sanitation and correction of pH, fertilization, stocking and feeding, all will interact and control the aquaculture production.

The water area and depth of the water column also affects the production of fish. The stage of quality recruitment, time of recruitment, density and ratio of species are also important in determining the productivity of a water body. Though the non availability of prawn and fish seed was a major constraint in earlier days, the development of environmentally controlled prawn/fish hatcheries made it possible to stock fish seeds in the reservoirs. With the spectrum of technologies already available, it is possible to adapt, modify and innovate to meet all the requirements for future hatchery developments.

In culturing fishes/prawns in captivity, nothing is more important than well balanced diet and adequate feeding. Diets can negatively influence the well being of a fish/prawn by inducing nutrient deficiencies, imbalances or by introducing infective agents into the prawns. The feeding with well balanced diets, not only results in good yields but also provides resistance against diseases. In some cases, a good quality diet may slow down the progress of idiopathic diseases. Hence, nutritionally balanced and quality controlled diets have prime importance in fish/prawn farming.

## 1.2. Scope of the present work

Only very little is known about the nutritional aspects of aquatic animal nutrition as it is still in a stage of infancy. Further it is riddled by so many interacting factors such as hydro-bio-geo and meteorological parameters. 50 to 60% of the operational cost in aqua culture is for feeds. Hence it is of great importance the evaluation of feed composition to maximise the output without any compromise in quality at an optimal cost. The raising of prawns to marketable size in impoundments within a short period through the provision of low cost feed continue to be a pressing problem in aquaculture research. It is necessary to provide prawns with essential and fortified feed to boost and maintain a high growth rate within a short period in the absence of natural feeds.

A balanced diet is one which contains required amounts of proteins, lipids, carbohydrates, fiber, minerals and vitamins. The percentage of requirements of these components vary from species to species and also within the same species. Larval feeds, grown out feeds and maturation feeds thus differ in their composition. Acceptability, palatability and digestibility are the key factors which need consideration in feed preparation. Size and stability of pelleted feeds are the important physical factors which governs the acceptability of the feed. An idealised feed conversion ratio from 1:1 to 1:1.5 at high energy needs can thus be obtained if all the factors act together.

There are several forms of prawn feeds: moist pellets, steam treated or extruded dry pellets and unformulated feeds such as ground liver, spleen, lung, heart, and raw fish (wet feed). However, only two basic types of formulated feed (artificial feed) need to be considered for intensive prawn culture, viz, moist and dry feeds. Though the moist feeds are superior in quality, it is susceptible to disintegration and can lead to deterioration of water quality by the possible dissolution of nutrients. The storage stability of the feeds are considerably poor and so the storage can be done only expensive by using freezer facilities. The labour requirements are also high. The moist feeds can be tried only in coastal regions where it will be advantageous due to the continuous availability of resource materials in the form of by products of sea food industries. The possible overheating during manufacturing can taper the nutritional quality of the dry feeds resulting in a low feed efficiency. But the availability of quality defined dry ingredients, the easing in the manufacture transport and store and the least damage it will bring into the water quality makes the dry feeds superior to moist feeds. All these advantages the dry feed have finally results in a cost effective operation

Success of large scale farming of marine animals hence, depends on the availability of cost-effective diets prepared from cheap natural products. The formulation of such a diet in a turn calls for basic information on nutritional requirement. In the case of studies on protein nutrition, the aim must be to assess the protein content of different commercially available ingredients. The combinations of locally available protein from low cost materials will meet the needs of the animal for optimal growth

An effective, simple and in expensive method was described for the preparation of a water stable diet, suitable as aquatic crustacean feed (Balazs et al.,1973). In captivity both caridean and penaeid prawns accept a wide variety of foods, however the flesh of mollucs and crustaceans has found the most acceptable, producing the best growth (Deshimaru and Shigeuno, 1972; Forster and Beard, 1973). Commercially the use of such food stuffs in many areas of intensive farming, would not normally be practical in many areas due to their high cost, insufficient availability and problems related to storage.

The feed conversion ratio varies according to the nutritional value of feed to the species and the most efficient ratios were observed with some of the imported feeds. Food is normally the largest single item in the running expenditure of a shrimp farm.

Large scale cultivation of prawn will depend to a considerable extent upon the formulation of pelleted diets which can be prepared reproducibly from cheap natural products and which have a defined shelf life. A better knowledge of the food chemistry of these feeds is essential for a maximum economic harvest. The formulation of such a diet, in turn, call for basic information on many nutritional factors.

The work incorporated in this thesis deals with the assessments the various chemical and biochemical characteristics of a large number of potential ingredients that are easily and continuously available in this region and of their formulations. The analysis of available biochemical factors in the feeds and their efficiency of conversion, stability of feed and growth response of prawns are described. The thesis is divided into 6 chapters.

Chapter I gives a general overview of the subject. An introduction on artificial feed for prawn culture has been given along with the research approach and scope of the present study.

Chapter II presents an exhaustive survey of the raw materials, the methods for the determination of biochemical components such as protein, fat, carbohydrate and calorific values, besides all other experimental details.

Chapter III gives the characteristics of the developed feeds. Protein has been considered to be the major criterion in the selection of an item as it happens to be the major nutritional factor and cost component in the prawn diet. A large number of items have been collected from animal and plant sources and subjected to proximate analysis for their nutritional content particularly for their protein and calorific values. Different combinations of selected ingredients have been tested to obtain maximum protein value at a minimum cost. The result of physical evaluation of the feeds like water stability, storage etc was presented with a comparison of these properties with different binders

Chapter IV describes the digestibility and growth response of the organism for the developed feed. The food conversion ratio, protein efficiency ratio and the growth parameters of the prawns in both the lab and farm culture were conducted. The results were compared with a standard diet.

Chapter V discusses the energetics of the organisms related to the formulated diet.

The salient features of the present investigation are summarized in chapter VI which is followed by a list of references.

# Chapter II

# MATERIALS AND METHODS

This Chapter gives a brief outline of the materials and methods employed in the present investigation.

## 2.1 Selection of ingredients and preparation of diets.

The preparation of experimental feeds was done based on earlier nutritional studies carried out in crustaceans (Kanazawa *et al.*, 1970, 1977; Deshimaru and Kuroki, 1974, Conklin *et al.*, 1977 ). A large number of materials were scanned and the items selected as potential ingredients are given in Table 2.1. The formulation of the diets from the selected ingredients were done after giving due consideration to their availability in areas prevalent in prawn farming and to the cost of the protein sources. Initially their toxic content was detoxicated to satisfactory levels by boiling in water for a few minutes. All the ingredients were either pulverized or ground using a hand mill and homogenised by a wet grinder. They were then mixed thoroughly in various proportions as shown in Table 2.2. 1g of Vitamins and minerals mix (pharmaceutical grade) were incorporated per 100g of feed.5g of pre gelatinised tapioca flour per 100g of feed was added to these ingredients and mixed well and steamed for 30 minutes in an ordinary steam cooker. The feed mash was then extruded into nodules through a pelletiser having nozzles of diameter 2-3 mm. The nodules were sun dried

Table 2.1
Percentage Nutritional values of the ingredients.

| Sl. No. | Items | Protein range % | Ash % | Fat % | CHO % |
|---|---|---|---|---|---|
| 1 | Avivinnia leaf meal | 13.50 - 15.55 | 10.34 | 2.0 | 74.14 |
| 2 | Clam Meat | 45.60 - 51.63 | 38.64 | 3.9 | 5.83 |
| 3 | Crotalaria leaf meal | 15.18 | 8.9 | 1.8 | 74.12 |
| 4 | Ehichornia leaf meal | 12.00 - 14.52 | 8.7 | 4.4 | 72.38 |
| 5 | Eupetorium leaf meal | 11.50 - 12.20 | 9.8 | 1.8 | 76.20 |
| 6 | Glyricidium leaf meal | 13.28 | 4.7 | 2.3 | 79.72 |
| 7 | Ground nut oil cake | 48.00 - 57.41 | 16.23 | 6.63 | 19.31 |
| 8 | Rhizophora leaf meal | 10.02 - 13.52 | 14.37 | 2.0 | 73.85 |
| 9 | Rice bran | 6.10 - 7.20 | 14.80 | 1.6 | 47.43 |
| 10 | Shrimp head meal | 45.00 - 52.40 | 33.05 | 7.3 | 7.25 |
| 11 | Slaughter House waste | 50.50 - 65.50 | 27.50 | 3.0 | 3.5 |
| 12 | Su-Babul leaf meal | 25.42 - 28.62 | 11.30 | 2.7 | 60.6 |
| 13 | Tapioca leaf meal | 24.00 - 30.45 | 7.50 | 6.5 | 62.0 |
| 14 | Thespesia leaf meal | 16.40 | 12.58 | 3.7 | 67.32 |
| 15 | Tapioca flour | 0.50 - 0.70 | 1.45 | 0.54 | 85.50 |
| 16 | Trash Fish Meal | 61.50 - 65.20 | 25.15 | 6.02 | 6.97 |
| 17 | Wheat flour | 11.50 - 12.06 | 42.07 | 8.03 | 29.5 |

Table. 2.2
Ratio of mixing of ingredients in the fromulated diets

| Sl.No | Items | Code no. | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | PD1 | PD2 | PD3 | PD4 | PD5 | PD6 | PD7 |
| 1 | Clam meat | 2.5 | | | 10.0 | 5 | 2.5 | 14.0 |
| 2 | Trash fish meal | 20.0 | 14.0 | 10. | 10.0 | | 20.0 | 14.0 |
| 3 | Shrimp Head Meal | 20.0 | 14.0 | 20.0 | 10.0 | 20.0 | 20.0 | 2.0 |
| 4 | Slaughter House Waste | 2.5 | 2.0 | 20.0 | 10.0 | 4.0 | 2.5 | 14.0 |
| 5 | Ground nut Oil cake | 20.0 | 14.0 | | | 10.0 | 20.0 | 14.0 |
| 6 | Wheat flour | 14.0 | 14.0 | 10.0 | | | | 13.0 |
| 7 | Rice Bran | 9.0 | 13.0 | 9.0 | 9.0 | | 9.0 | 14.0 |
| 8 | Tapioca flour | 5.0 | 14.0 | 10.0 | 10.0 | 10.0 | 5.0 | 13.0 |
| 9 | Su- Babul leaf Meal | | | | 10.0 | | 20.0 | 14.0 |
| 10 | Tapioca leaf meal | 20.0 | 14.0 | 20.0 | 10.0 | | | 14.0 |
| 11 | Glyrecidium Meal | | | | | 10.0 | | |
| 12. | Thespesia meal | | | | 10.0 | 10.0 | | |
| 13 | Avicinnia meal | | | | 10.0 | | | |
| 14. | Rhizophora meal | | | | 10.0 | 10.0 | | |
| 15. | Crotalaria meal | | | | | 10.0 | | |
| 16. | Eichornia meal | | | | | 10.0 | | |
| 17. | Mineral Mix/Vitamins | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |

to a moisture level of 7.5 to 10, broken to pieces of 1" length and stored in polythene bags at room temperature.

## 2.2 Physical evaluation.

A technique which is similar to that developed by Hasting (1971), was used for the measurement of the stability of the formulated diets in water. The feeds were tested in triplicate by dropping 1 g each of pellets gently into 250 ml beakers containing 200 ml of water. Individual sets were maintained for estimation at the time intervals 1,3,5, and 7h. Each of the sample was filtered, and the residue was dried at $80^0$C for 10 h and weighed . The difference between the initial and final weights in each experimental period gave the stability of the feeds in that hour interval.

The binding efficiencies of the different binders and the effect of concentration of binder on the water stability of the feeds also were done by the same methods.

## 2.3 Collection and acclimation of test animals.

Juveniles of shrimps *Penaeus indicus, Penaeus monodon and Metapenaeus dobsoni*, the test animals selected were collected from Azhikode hatchery, located at northern end of the Cochin estuary, Kerala and were of known nutritional history. The collected animals, were transported to the laboratory without causing strain. Healthy animals were selected and sorted out according to their activity and required size. The sorted animals were stocked in fiber glass tanks and were acclimated to laboratory conditions for two days. These animals were starved for 24 hours prior to the feeding experiments.

## 2.4 Water management.

The estuarine water was used for rearing the animals in the feeding experiments. The water was filtered through bolting cloth and stored in large tanks of 1000 liter capacity. Intermittent aeration had been provided with the help of 5 HP autostop pressure adjusted oil-free air compressor channeled through PVC pipes and diffusion stones. The air supply was maintained uniformly throughout the experimental period, except during the cleaning of the tanks and the removal of left over feeds and faecal matters. Since the early juveniles of peneaid prawns were found to have the maximum growth and survival at salinity 15 to $23X10^{-3}$(Venkataramiah *et al.*, 1975a) the salinity of the water in the large tanks was kept in the range $20\text{-}23X10^{-3}$and this water was used in all feeding experiments in the laboratory.

## 2.5 Culture Studies

### 2.5.1. Laboratory Culture studies

To assess the suitability of the diets as prawn feeds, preliminary feeding trials were carried out on the juveniles of prawns in the laboratory. The trials were conducted in 5 sets with varying size groups of animals. Each set and its replicate consisted of 20 animals, kept in plastic tanks containing esturine water. The studies were carried out for 30 days. The method of feeding the animals, collection and computating the data were done by the method given by Royan *et al.* (1977).From the trial runs, five feed formulations were selected for further studies taking into consideration the growth response and the cost factor. The culture experiments were divided into two category, laboratory culture and field culture. The laboratory culture studies were conducted in both in low density(10juvenile per tank) and high density (100juvenile per tank). Both the low density and the high density (90 days duration) experiments were carried out in the laboratory using plastic tanks,covered with nylon screen,to prevent the escape of the animals. Each tank was 100 liter capacity filled with a constant volume of 75 liter of filtered estuarine water. Aeration was provided with the help of a compressor and water was changed in every 15 days. A uniform aeration was given through out the experimental period.

2.5.2 Field Culture studies.

The prepared diets were examined under pilot scale commercial conditions. Approximately(10000/Are in paddy field and 25,0000 juveniles esturine fish pondfield) were used. The duration of the experiment was 90 days. Increase in body length and weight of prawns was used as a measure of growth, and a sample of 100 animals was measured at the end of 90 days experimental period.

2.6. Feeding schedule.

The juvenile prawns were fed with formulated diets at the rate of 10 % (by dry weight) of the live body per day as suggested by Subramanyam and Oppenheimer (1970). The feeding was done in the morning and in the evening in equal proportions, viz 10. 00 h and 17.00 h . The amount of feed given was adjusted to every 15 th day of the experiment based on changes in the body weight. When the prawns were small the pellets were broken into a crumble to facilitate their manipulation and acceptance by the prawns. Estimation of water quality was done periodically. Juveniles of similar size were selected and used in an effort to compensate the variability in individual growth rate. Each treatment was replicated thrice. Prawns were observed to respond readily to the pellets, which were normally ingested totally within 2-3 h. Diets were evaluated on the basis of growth and survival data after being fed with the test diets for 30, 60 and 90days. All surviving animals were individually weighed on a top loading balance of accuracy 0.01

g. Faecal strands were collected from the tanks 3 to 5 h after the feed application.

## 2.7 Collection of left over food and faecal matter

The left over food and faecal matter were daily collected from the tank by slow siphoning of the water through a narrow glass tube and collected at the other end on a bolting silk. The faecal matter and left over food, which were collected separately, were washed in distilled water to remove the adhering salts, transferred to pre -weighed aluminium foils and kept for drying at 70°C for 48 hours. The dried samples were weighed and the dry weights were recorded. The samples were stored in a desiccator for subsequent analyses. The dry samples were powdered by a porcelain mortar and pestle and the biochemical composition was studied.

## 2.8 Analytical methods.

Analysis of proximate composition of feed, excreta and body flesh was performed by employing standard AOAC (1980) methods. All analyses were done in duplicate.

### 2.8.1 Routine measurements.

Temperature, pH, salinity and dissolved oxygen of water samples were determined by employing standard methods (Grasshoff *et al.*,1983). A mercury bulb thermometer and an Elico model pH meter (accuracy ± 0.05 pH units) were used for the measurements of temperature and pH respectively of the water samples. Salinity was determined by using the Mohr-Knudsen titrimetric method and dissolved oxygen by the Winkler method (Grasshoff *et al.*, 1983). The mean temperature , salinity, pH, and dissolved oxygen observed during the period of experiment are shown in

Table 2.3 which were well within the established tolerance limits of prawns (Wickins,1972; Colvin, 1976; Delistraty *et al.*, 1977)

2.8.2 Analysis of Biochemical constituents.

Analysis of Biochemical constituents were carried out to elucidate the nutritive values of different ingredients used and also to formulate the feeds with different dietary levels of proteins, carbohydrates and lipids. The estimation of protein, lipids, carbohydrates, ash, moisture and calorific value was performed by following standard methods.

Total nitrogen was determined by Micro kjeldhal method in which sample was digested in concentrated $H_2SO_4$ and the resulting ammonium nitrogen was determined by titrating against a standard $H_2SO_4$ solution. The total nitrogen content multiplied by 6.25 was taken as the crude protein content.

The crude fat was determined by extraction with petroleum ether (boiling point, 40-60$^{o}$C) in a soxhlet apparatus for 6 hours

The carbohydrate was calculated by subtracting the percentage of all other components put together from 100. The proximate compositions of all the ingredients and feeds (except moisture content) were expressed on dry weight basis.

The energy values of feed and faecal matter were determined by using the method of Karzinkin and Tarkovskaya (1964) and the metabolisable energy value was calculated on the following energy values; 4.10 kcal/g for carbohydrate, 9.10 kcal/g for lipid and 5.5 kcal/g for protein (ADCP, 1983). The energy values are expressed in kJ $g^{-1}$.

Table 2.3
Hydrographical data of the feeding experiments

| Salinity | Oxyge cc/l | pH | Temperature oC |
|---|---|---|---|
| 23*10 | 4.6 | 8.05 | 28.5 |
| 23*10 | 4.5 | 8.05 | 30.2 |
| 23*10 | 4.1 | 8.2 | 29.5 |

## 2.9 Moisture content

The Moisture content was determined by drying the sample at 105$^{o}$C until a constant weight was reached. The ash content was determined by incinerating the sample at 600$^{o}$C for 6 hours in a furnace.

## 2.10 Estimation of Metals.

The metal solutions of copper, zinc and Manganese (1000ppm) were prepared from 99.9% pure metals (BDH AnalaR - grade). The oxide layers on the surface of the metals were cleaned off using dilute $HNO_3$ (0.1 N $HNO_3$) and dried using acetone. 1 gm each metal were weighed into 50 ml beakers separately and brought into solutions using minimum quantity of concentrated 1:1 $HNO_3$. Excess acid was evaporated off by gently warming the solutions, cooled and made up to 1000 ml using double distilled water.

### 2.10.1 Digestion procedure for the determination of Cu, Zn, and Mn.

The digestion procedure was basically that of Martincic *et al.* (1984). 0.1 to 2.0 g of dried sample was digested in a 100ml ml Kjeldhal flask with 5 to 10ml conc. $HNO_3$ and 0.5 to 1 ml $HClO_4$ until the organic matter was completely destroyed, indicated by a clear solution in the flask. The solution was cooled and diluted to a specific volume with double distilled water.

### 2.10.2 Determination of Cu, Zn, Mn.

Cu and Zn and Mn were estimated using atomic absorption spectrophotometer (Perkin -Elmer 2380).

## 2.11 Evaluation Criteria.

The following parameters were employed for the evaluation of the data obtained.

1. Percentage survival.

The percentage survival of prawns was calculated at the end of each sampling period and the termination of each experiment for each tank, and the mean was computed as follows.

$$\text{Percentage Survival} = \frac{(\text{Initial No. of prawns} - \text{No. of prawn dead}) \times 100}{\text{Initial No. of prawns.}}$$

2. Growth rate.

Growth in prawns is expressed as absolute gain in weight, percentage of growth rate or more recently as specific growth rate (GW).

$$GW\ \% = \frac{\text{In } W_1 - \text{In } W_0}{t} \quad X100.$$

Where,
$W_1$ is the mean weight (g) of the prawn at the end of each sampling period, Wo is the mean weight (g) of the prawn at the beginning of sampling period and t is the duration in days of the corresponding sampling period.

3. Food conversion ratio

$$FCR = \frac{W_c}{W_g}$$

where,
$W_g$ is the Wet weight gain of prawn (g) during the sampling period and $W_c$ is the dry weight of food consumed (c) during the sampling period.

4. Protein digestibility.

Protein digestibility was expressed both in terms of apparent digestibility and true digestibility. Apparent digestibility of protein was calculated by employing the formula,

$$\text{Apparent digestibility (\%)} = \frac{\left[Q_c - Q_f\right] \times 100}{Q_c}$$

Where,

$Q_c$ is the quantity of protein consumed and $Q_f$ is the quantity of protein in the faeces.

5. Efficiency of protein utilization.

Efficiency of protein utilization was expressed as protein efficiency ratio (PER) and was calculated by employing the formula given by (Hepher,1988).

$$\text{Protein efficiency ratio (\%)} = \frac{\text{Wet weight gain of prawn (g)}}{\text{Crude protein fed (g)}}$$

6. Energy retention ratio.

$$\text{Energy retention ratio (\%)} = \frac{\text{Energy gain} \times 100}{\text{Energy intake}}$$

7. Energy utilisation ratio.

$$\text{Energy utilization ratio (\%)} = \frac{(\text{Energy assimilated} - \text{Energy gained}) \times 100}{\text{Energy assimilated}}$$

# Chapter III

Presentation of feed to prawn is an important aspect in the prawn dietary practice. The form of feed depends on the stage of growth and culturing methods. There are several forms of prawn feeds (i) gels, (ii) paste, (iii) steam compressed pellets, (iv) flakes, (v) capsules, and (vi) shaghetti like extrusion. Moist feeds lead to water quality and pollution problems due to the disintegration of pellets and the possible dissolution of nutrients. They are also expensive in terms of labour requirements and freezer facilities required for storage. Moist feeds have some merit in coastal regions, where the fresh raw fish as byproduct and labour are regularly available and may have a significant economic advantage (Bromely, 1980). Extruded dry feed may be of inferior nutritive quality because of the possible overheating during the manufacturing process. In comparison with moist diets, dry feeds are easy to manufacture, transport and store. Bulk purchase of quality feed ingredients enables continuous supply of quality feed. The dry ingredients in the commodity market are more quality defined, hence it is possible to formulate dry feeds precisely using the available knowledge on prawn nutrition. Further, this will lead to the formulation of "least-cost" prawn diet.

The formulation of a diet represents the transformations of energy and nutrient requirements into a balanced mixture of feed ingredients for a group of animals. This diet should then meet the requirements of daily need for energy and nutrients to support the maintenance, growth and survival of the animal.

A variety of sources of protein and the substitution effects of one source with another in various species of shrimp and prawn have been evaluated by various workers with varying degrees of success. Diets based on chemically defined ingredients have been compared to those containing one or more natural raw materials or casein, Yeast and soy hydrolysates (Sick *etal*.,1972). *Penaeus aztecus* grew little on diets with casein as the major protein source, except when supplemented with minerals, and gave much poorer results than similar diets for *Penaeus japonicus* (Kanazawa *et al.*,1970). Reports of use of casein incorporated with or without crystalline amino acids or other protein sources as test diets to study the nutritional requirements of many species of crustaceans have also been published (Civera and Guillaume, 1989; Morrissy, 1989; Reed and D' Abramo, 1989; Reigh and Stickney 1989). Sultan *et al.* (1982) obtained encouraging results using frog flesh waste as a protein source in the feed for *Penaeus indicus* and *Penaeus monodon*. Goswami and Goswami (1979, 1980) pointed out the possibilities of use of slaughter house waste in shrimp diets. Protein digestibility was positively correlated with its level in the diet (Condrey *et al.*, 1972; Nose, 1964). The reports on the protein level for penaeid diets are conflicting, because of the differences in the composition of the diets used.

Dietary lipids serve as a source of essential fatty acids (EFA) and energy. In addition, they also act as carriers for the fat - soluble vitamins. Many workers have investigated the effect of dietary lipid on the growth of marine animals. The importance of lipid in prawn and shrimp nutrition was reviewed by New (1976). The requirement of different classes of lipids,fatty acids , phospho lipids and steroids for different species of penaeid prawns are reviewed by Kanazawa (1984). Ahamed Ali (1990) reported the identification of four different lipids and their relative efficiencies in the diets of Indian white prawn *Penaeus indicus*.

Carbohydrate is a cheap source of energy in the diet of animals, including that of fish and prawn. Carbohydrate digestion in crustacea has been demonstrated by Kooiman (1964) and the presence of many carbohydrates including $\alpha$ and $\beta$ amylase, maltase, saccharase, chitinase and cellulase has been reported. Strong carbohydrase activity has been shown in the herbivorous shrimp, *Macrobrachium dayanum* (Tyagi and Prakash, 1967).

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Metabolism of minerals differs from that of other nutrients like proteins, carbohydrates, fats and vitamins, in that minerals are not produced by the organism. The mineral requirement of crustaceans may be considerable because of the reported losses incurred during molting. Published literature on the role of minerals in shrimp nutrition is scarce, although many workers have used mineral supplements in the diets for prawns. The application of vitamin mixes to shrimp diet without the required knowledge may not only be economically wasteful but dangerous. Excess of some vitamins may be toxic or antagonistic to shrimp.

A range of natural and synthetic materials has been used to improve water stability of shrimp feeds. Water stability is desirable because of the intermittent feeding behavior of shrimps and to enable preservation of water quality. The physical nature and the solubility of the diet have a significant impact on ingestion. Many substances have been employed as binding agents in shrimp diets so that they will not lose their texture by leaching unduly in warm, fresh or saline waters. The binders are generally long chain macromolecules which are not digested or disintegrated in the gastrointestinal tract of animals. However, earlier studies with alginate and guargum have shown that these binders lowers the digestibility of the feed (Hodgkinson *et al.*, 1967; Viola *et al.*, 1970; Harmuth-Hoene and Schelenz, 1980; Wobling *et al.*, 1980). The influence of these and few other binders has led to a search for binder which can modify the nutritional content and assist the uptake and assimilation of the feed (Storebakken and Austreng, 1987).

The storage of feed ingredients and diets is another step in maintaining the quality of compounded feeds. The intake and utilization of feed depend upon the physiological state of the organism. The nutrient composition of the feed ingredients, their cohesive ability on long storage, stability of nutrients in the feed when introduced in water and attractability of the feed are some of the factors which influence the growth performance of crustacean (Meyers *et al.*, 1972; Meyers and Zein-Eldin, 1972; New, 1976; Biddle, 1977; Hanson and Goodwin, 1977).

The present investigation was an attempt to formulate prawn feeds of comparable nutritional status and digestibility from naturally occurring and easily available nutrient rich plant and animal materials.

## MATERIALS AND METHODS

Materials and methods are described in Chapter II.

## RESULTS AND DISCUSSION

Based on a brief survey with due consideration to the availability, general nutritive expectations and the cost element, natural materials from both plant and animal sources were identified for the formulation of feeds. The selected ingredients were subjected to proximate analysis for their nutritional content and calorific values. The results are presented in Table 3.1. Among the ingredients,those from animal sources recorded a high protein content, the highest being 65.2% for trash fish meal and the lowest 45% for shrimp head meal. The ingredients from plant sources generally exhibited a protein content in the range of 10-30%. A high protein value of 57.41% was shown by ground nut oil cake and a very low value of 0.5% by tapioca flour.

The maximum value for the carbohydrate content (85.50%) was given by the tapioca flour and the lowest value (3.50%) was given by slaughter house waste. The fat content was the highest in wheat flour (8.03%) and the lowest in tapioca flour (1.54%).

Table 3.1
Percentage Nutritional values of the ingredients.

| Sl. No. | Items | Protein range % | Ash % | Fat % | CHO % | Calorific value Kj/g |
|---|---|---|---|---|---|---|
| 1 | Avivinnia leaf meal | 13.50 - 15.55 | 10.34 | 2.0 | 74.14 | 6.3118 |
| 2 | Clam Meat | 45.60 - 51.63 | 38.64 | 3.9 | 5.83 | 18.5174 |
| 3 | Crotalaria leaf meal | 15.18 | 8.9 | 1.8 | 74.12 | 7.19252 |
| 4 | Ehichornia leaf meal | 12.00 - 14.52 | 8.7 | 4.4 | 72.38 | 3.47149 |
| 5 | Eupetorium leaf meal | 11.50 - 12.20 | 9.8 | 1.8 | 76.20 | 6.99481 |
| 6 | Glyricidium leaf meal | 13.28 | 4.7 | 2.3 | 79.72 | 6.32434 |
| 7 | Ground nut oil cake | 48.00 - 57.41 | 16.23 | 6.63 | 19.31 | 21.9700 |
| 8 | Rhizophora leaf meal | 10.02 - 13.52 | 14.37 | 2.0 | 73.85 | 5.48834 |
| 9 | Rice bran | 6.10 - 7.20 | 14.80 | 1.6 | 47.43 | 11.4197 |
| 10 | Shrimp head meal | 45.00 - 52.40 | 33.05 | 7.3 | 7.25 | 17.2425 |
| 11 | Slaughter House waste | 50.50 - 65.50 | 27.50 | 3.0 | 3.5 | 16.1682 |
| 12 | Su-Babul leaf meal | 25.42 - 28.62 | 11.30 | 2.7 | 60.6 | 5.96486 |
| 13 | Tapioca leaf meal | 24.00 - 30.45 | 7.50 | 6.5 | 62.0 | 26.4176 |
| 14 | Thespesia leaf meal | 16.40 | 12.58 | 3.7 | 67.32 | 7.16034 |
| 15 | Tapioca flour | 0.50 - 0.70 | 1.45 | 0.54 | 85.50 | 9.6976 |
| 16 | Trash Fish Meal | 61.50 - 65.20 | 25.15 | 6.02 | 6.97 | 15.9968 |
| 17 | Wheat flour | 11.50 - 12.06 | 42.07 | 8.03 | 29.5 | 15.6959 |

The calorific value was found to be the highest for tapioca flour (26.41 Kj/g) where and lowest for Ehichornia leaf meal (3.47 kj/g).

Protein is considered as the limiting nutrient and the selected ingredients were mixed in various proportions for the synthesis of the diets giving due considerations to the final protein value (Table 3.2) From the growth response of an intial feeding trial, five formulations were selected for further study. The final products were labelled PD1, PD2, PD3, PD4 and PD5. The results of the analysis of the nutritional factors viz protein, lipid and carbohydrates and the moisture and ash content has given in Table 3.3. Among the five formulated diets the PD5 has been the highest protein value (42.20%) and the PD1 has the least (30.08%). The carbohydrate and the crude fat levels were found to be highest in PD1 (39.84% and 5.93% respectively). The PD3 registered the highest ash content (13.04%).

The water stability of the five formulated and the standard feeds for the 7h period has been presented in the Table 3.4 & Fig 3.1. The maximum stability was observed with PD2 (88.95%/7h) and the lowest for the standard feed (66.96%/7h). The percentage retention of the formulated feeds for different binders at varying percentages has been given in Table 3.5 and in Figure 3.2. The maximum retention was observed for the feed with 3% of sodium alginate followed by 2% tapioca powder. The relative order of stability was sodium alginate > tapioca powder > agar > gelatin > mytha > rice powder.

Result of the water stability test has shown that the pellets became harder on drying in relation to quantitative increase of binder. Measurements of stability at different periods of immersion such as 1h, 3h, 5hr and 7h showed that with rice and mydah flour as binder pellets was retained 83-84% stability up to 7h by the addition of binder at 5% level.

Table 3.2
Ratio of mixing of ingredients (%) in the fromulated diets

| Sl.No | Items | PD1 | PD2 | PD3 | PD4 | PD5 |
|---|---|---|---|---|---|---|
| | | Feed Used | | | | |
| 1 | Clam meat | 2.5 | | | 10.0 | 5.0 |
| 2 | Trash fish meal | 20.0 | 14.0 | 10.0 | 10.0 | |
| 3 | Shrimp head meal | 20.0 | 14.0 | 20.0 | 10.0 | 20.0 |
| 4 | Slaughter house waste | 2.5 | 2.0 | 20.0 | 10.0 | 4.0 |
| 5 | Ground nut oil cake | 20.0 | 14.0 | | | 10.0 |
| 6 | Wheat flour | 14.0 | 14.0 | 10.0 | | |
| 7 | Rice bran | 9.0 | 13.0 | 9.0 | 9.0 | |
| 8 | Tapioca flour | 5.0 | 14.0 | 10.0 | 10.0 | 10.0 |
| 9 | Su- babul leaf meal | | | | 10.0 | |
| 10 | Tapioca leaf meal | 20.0 | 14.0 | 20.0 | 10.0 | |
| 11 | Glyrecidium meal | | | | | 10.0 |
| 12. | Thespesia meal | | | | 10.0 | 10.0 |
| 13 | Avicinnia meal | | | | 10.0 | |
| 14. | Rhizophora meal | | | | 10.0 | 10.0 |
| 15. | Crotalaria meal | | | | | 10.0 |
| 16. | Eichornia meal | | | | | 10.0 |
| 17. | Mineral mix/Vitamins | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |

Table 3.3 Biochemical composition of feeds (%).

| Item | Moisture | Protein | Fat | Carbohydrate | Ash |
|---|---|---|---|---|---|
| STD | 5.32 | 27.80 | 8.82 | 26.20 | 14.11 |
| PD1 | 6.30 | 30.08 | 5.93 | 39.84 | 11.44 |
| PD2 | 8.80 | 33.70 | 4.37 | 36.37 | 10.22 |
| PD3 | 7.70 | 31.40 | 3.83 | 33.34 | 13.04 |
| PD4 | 9.30 | 40.09 | 3.27 | 29.27 | 12.04 |
| PD5 | 10.20 | 42.20 | 3.67 | 26.55 | 11.05 |

Table 3.4
Stability of formulated and standard feeds

| Test Feed Code No | Dry wt. taken(g) | 1 h | | 3 h | | 5 h | | 7 h | |
|---|---|---|---|---|---|---|---|---|---|
| | | wt of dissolved matter(g) | % retained | wt of dissolved matter(g) | % retained | wt of dissolved matter(g) | % retained | wt of dissolved matter(g) | % retained |
| PD1 | 1.00 | 0.08 | 91.63 | 0.15 | 84.67 | 0.16 | 83.70 | 0.16 | 83.53 |
| PD2 | 1.00 | 0.04 | 96.27 | 0.10 | 89.70 | 0.11 | 89.04 | 0.11 | 88.95 |
| PD3 | 1.00 | 0.12 | 88.44 | 0.13 | 87.27 | 0.19 | 80.96 | 0.20 | 80.57 |
| PD4 | 1.00 | 0.08 | 92.33 | 0.13 | 87.00 | 0.14 | 85.67 | 0.14 | 86.00 |
| PD5 | 1.00 | 0.14 | 85.67 | 0.17 | 82.67 | 0.20 | 80.00 | 0.22 | 78.00 |
| STD | 1.00 | 0.27 | 73.42 | 0.30 | 69.57 | 0.33 | 0.00 | 0.33 | 66.96 |

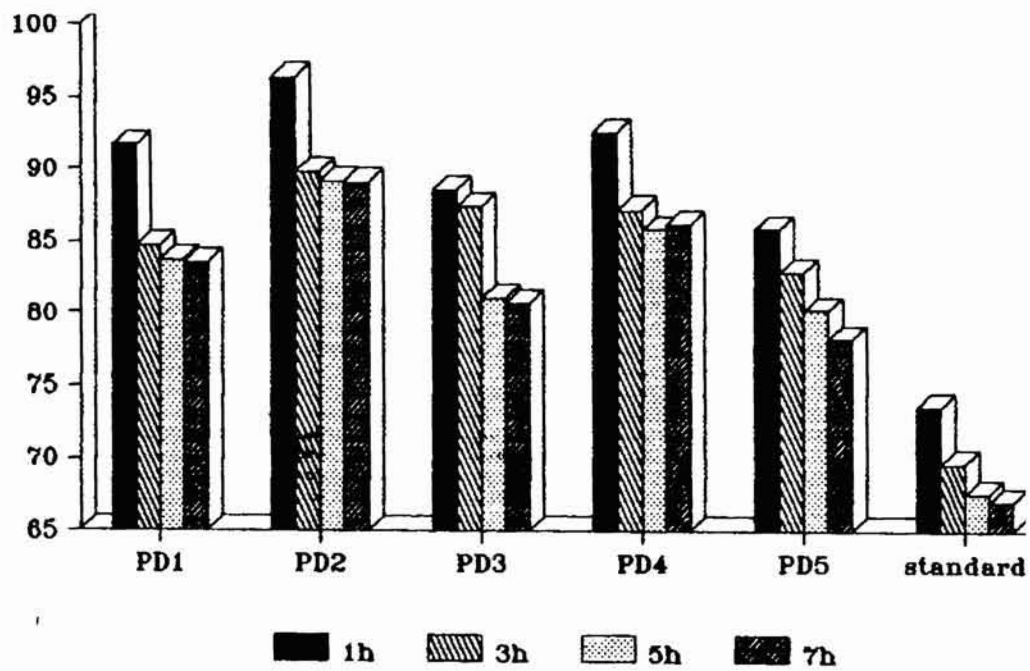


Fig.3.1 Stability of Formulated and Standard Feeds.

Table 3.5
The effect of binder on the sinking rate and stability of formulated feeds

| Name of the binder | % of the binder used | Dry wt of feed (g) | 1 h | | 3 h | | 5 h | | 7 h | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Dissolved feed (g) | % retained | Dissolved feed (g) | % retained | Dissolved feed (g) | % retained | Dissolved feed (g) | % retained |
| | 5.00 | 5.00 | 0.41 | 91.87 | 0.56 | 88.87 | 0.73 | 85.41 | 0.80 | 83.94 |
| Rice Powder | 10.00 | 5.00 | 0.40 | 92.09 | 0.45 | 91.03 | 0.68 | 86.33 | 0.70 | 86.02 |
| | 15.00 | 5.00 | 0.32 | 93.66 | 0.42 | 91.59 | 0.63 | 87.36 | 0.69 | 86.13 |
| | 20.00 | 5.00 | 0.30 | 93.93 | 0.42 | 91.69 | 0.63 | 87.46 | 0.68 | 86.33 |
| | 5.00 | 3.00 | 0.17 | 94.44 | 0.26 | 91.33 | 0.28 | 90.51 | 0.30 | 90.11 |
| Tapioca Powder | 10.00 | 3.00 | 0.13 | 95.51 | 0.25 | 91.78 | 0.25 | 91.54 | 0.29 | 90.47 |
| | 15.00 | 3.00 | 0.11 | 96.28 | 0.24 | 92.00 | 0.25 | 91.63 | 0.25 | 91.60 |
| | 20.00 | 3.00 | 0.10 | 96.70 | 0.21 | 92.92 | 0.22 | 92.62 | 0.24 | 92.07 |
| | 5.00 | 5.00 | 0.41 | 91.77 | 0.59 | 88.13 | 0.73 | 85.40 | 0.82 | 83.53 |
| Mytha powder | 10.00 | 5.00 | 0.38 | 92.36 | 0.49 | 90.16 | 0.69 | 86.14 | 0.72 | 85.69 |
| | 15.00 | 5.00 | 0.32 | 93.67 | 0.44 | 91.16 | 0.64 | 87.17 | 0.69 | 86.15 |
| | 20.00 | 5.00 | 0.31 | 93.83 | 0.42 | 91.59 | 0.63 | 87.39 | 0.67 | 86.64 |

Table 3.5 contd...

Table 3.5 (contd.)

| Name of the binder | % of the binder used | Dry wt of feed (g) | 1 h | | 3 h | | 5 h | | 7 h | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Dissolved feed (g) | % retained | Dissolved feed (g) | % retained | Dissolved feed (g) | % retained | Dissolved feed (g) | % retained |
| | 1.00 | 3.00 | 0.13 | 95.62 | 0.23 | 92.22 | 0.28 | 90.80 | 0.30 | 89.90 |
| Sodium | 2.00 | 3.00 | 0.13 | 95.80 | 0.21 | 93.07 | 0.26 | 91.18 | 0.28 | 90.57 |
| Alginate | 3.00 | 3.00 | 0.09 | 96.86 | 0.17 | 94.39 | 0.22 | 92.81 | 0.23 | 92.38 |
| | 1.00 | 3.00 | 0.26 | 91.21 | 0.27 | 90.89 | 0.29 | 90.20 | 0.28 | 90.56 |
| Agar | 2.00 | 3.00 | 0.26 | 91.26 | 0.27 | 91.00 | 0.29 | 90.31 | 0.32 | 89.22 |
| | 3.00 | 3.00 | 0.26 | 91.53 | 0.27 | 91.23 | 0.29 | 90.37 | 0.32 | 90.33 |
| | 1.00 | 3.00 | 0.28 | 90.68 | 0.29 | 90.49 | 0.30 | 90.13 | 0.30 | 89.97 |
| Gelatin | 2.00 | 3.00 | 0.25 | 91.51 | 0.29 | 90.46 | 0.29 | 90.50 | 0.31 | 89.68 |
| | 3.00 | 3.00 | 0.24 | 92.00 | 0.26 | 91.31 | 0.27 | 91.03 | 0.31 | 89.57 |

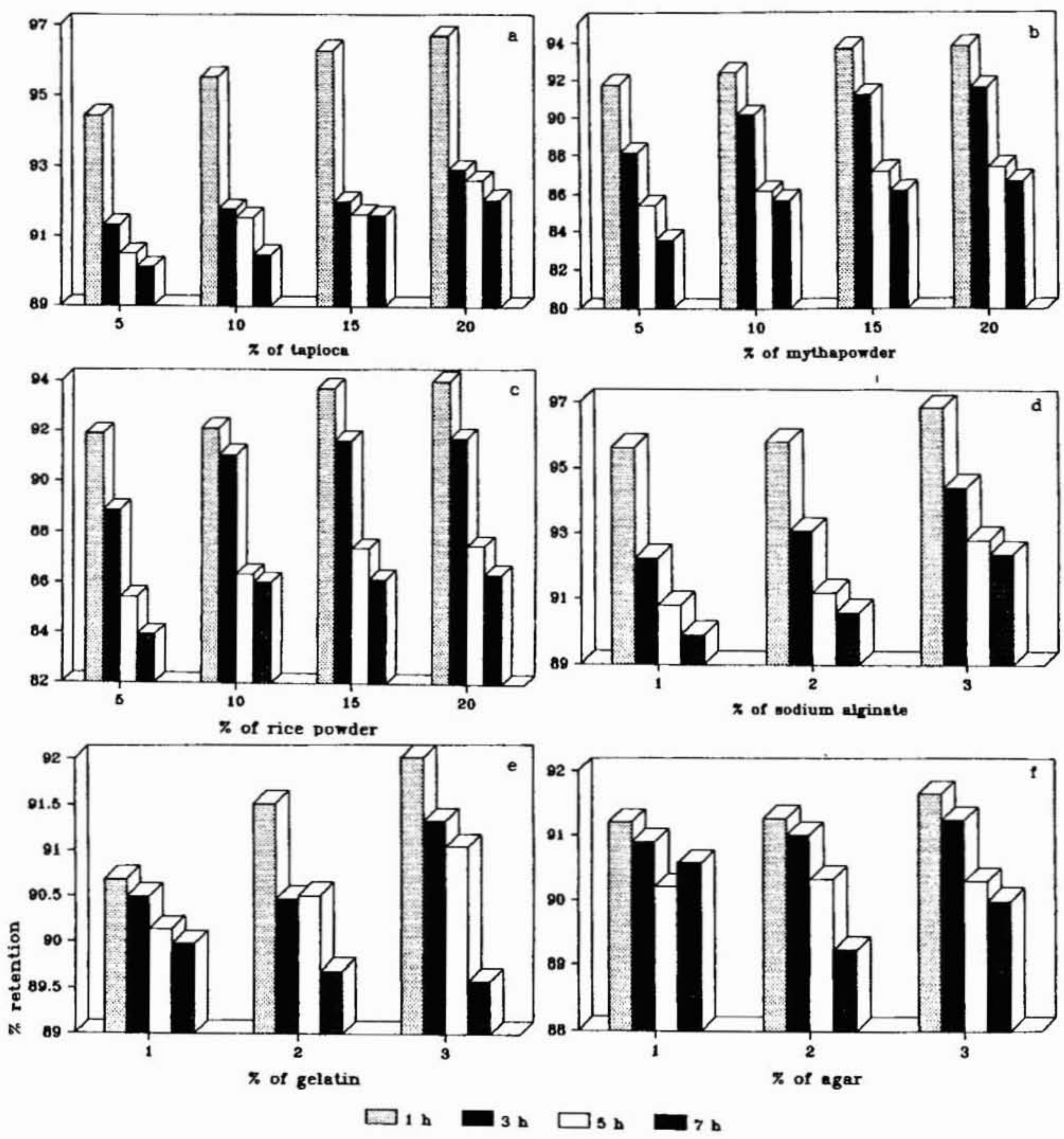


**Fig. 3.2 Percentage of formulated feed for different binders at varying percentage**

Increasing the quantity of the binder up to 20% level, could not seriously alter the stability. Most of the feeds in a controlled feeding (10%) system, were consumed within a period of 3h. A pellet stability of nearly 90% was obtained by the addition of jelled starch at 5-10% level, which is practically very significant in the preparation of aqua feeds at cottage level. With regard to tapioca flour as the binder pellet, stability of nearly 90% was attained for a period up to 7h when the binder was added at 5% level. Here also,increasing the quantity of binder up to 20% did not provide notable additional stability.

A comparison of sodium alginate and agar as binding agents at 1%, 2% and 3% levels, showned that sodium alginate was better than agar for a short duration. At 1% level sodium alginate gave more than 95% stability at the end of 1h and nearly 90% stability at the end of 7h,whereas agar gave more than 90% stability at the end of 1h and the same almost retained up to the end of 7h. Agar seems to be advantageous in the case of slow feeding aquatic organisms.

Details with regard to variation in the nutritive components of different feeds after storage for a 6 month periods are give in the Table 3.6. At the end of 6 months storage moisture content had increased in all the 6 feeds. It means the protein content, fat and ash content decreased. The difference in the carbohydrate content is directly linked to the changes in other components during storage.

DISCUSSION

The effectiveness of a prawn feed depends on the various feed characteristics like composition, quality of the nutritional factors, water stability and the palatability. Along with an optimum nutritional status in terms of protein, carbohydrates and lipid, to ensure the supply of these essential

Table 3.6
The effect of storing on the nutritional content of the feeds

| | Moisture | | Protein | | Fat | | Carbohydrate | | Ash | |
|---|---|---|---|---|---|---|---|---|---|---|
| Months / Item | 0 | 6 | 0 | 6 | 0 | 6 | 0 | 6 | 0 | 6 |
| STD | 5.32 | 10.22 | 27.80 | 24.50 | 8.82 | 5.60 | 26.60 | 25.04 | 14.11 | 14.22 |
| PD1 | 8.80 | 9.22 | 30.08 | 29.10 | 5.83 | 3.12 | 36.37 | 35.03 | 10.22 | 10.45 |
| PD2 | 6.30 | 8.69 | 33.70 | 30.20 | 4.37 | 4.24 | 39.84 | 38.14 | 11.44 | 12.01 |
| PD3 | 7.70 | 8.75 | 31.40 | 28.30 | 3.83 | 2.46 | 33.34 | 32.44 | 13.04 | 13.05 |
| PD4 | 9.30 | 10.26 | 40.90 | 38.52 | 3.27 | 2.17 | 29.27 | 24.12 | 12.04 | 12.01 |
| PD5 | 10.20 | 12.24 | 42.20 | 39.17 | 3.67 | 2.17 | 26.55 | 23.05 | 11.05 | 11.07 |

nutrients to the prawns in the required quantity, the diet prescribed should have the correct appearance (size, shape and color), texture (hard, soft, moist, dry, etc.), feeding density (buoyancy) and attractiveness (smell or taste). The purely chemically defined diet, which can replace the well derived and proved biological feed - the clam meat, was found to be less effective (Kanazawa *et al.*, 1970). The omnivorous nature of most of the prawns had led in the continuous effect to prepare economically feasible and nutritionally acceptable diets by altering the various components that constitute the feed.

The Success of large scale farming of marine animals, hence, depends on the availability of cost - effective diets prepared from cheap natural products. The formulation of such a diet in turn calls for basic information on nutritional requirements. The combinations of locally available protein from low cost materials will meet the needs of the animal for optimal growth. In the case of studies on protein nutrition, the aim must be to assess the protein content of different commercially available feeds. In this study, the protein content in the formulated feeds were kept in the range 30-42%, which is well within the range suggested by many of the earlier workers for an optimal growth of penaeid prawns (Cheriyan *et al.*, 1991). The source of the protein was found to determine the quality of the protein in the formulated feeds with respect to its conversion efficiencies and it is well established that fish protein is the best source of protein for the shrimp culture (Viola, 1975; Ahamed Ali, 1988a; Shiranee Pereira *et al.*, 1990). The high protein content, acceptability and the reported high efficiency of the fish meal were the major considerations in including the fish meal as one of the ingredients. The plant protein was observed to increase the assimilation and growth efficiency of animal protein (Venkataramiah *et al* .,1975b). This observation along with the continuous availability and low cost of the source led to the incorporation of plant leaves into the feed.

Though prawn waste is rich in proteins, the chitin and calcium present in the prawn exoskelton was suggested to have deleterious effects on the overall nutrition (Miranda and Horowitz, 1978, Simpson *et al.*, 1981). However, the chitinous materials were observed to increase the palatability of the feed by imparting a pleasing smell (Colvin, 1976 , Ahamed Ali, 1982a) and the prawn waste in compounded ration was reported to be promising (Venkataramiah *et al.*, 1978, Ahamed Ali, 1988b). The earlier observations along with the comparable nutritional status shown in terms of proteins, carbohydrates, and lipids were the basis of inclusion of prawn waste in the formulated feeds of this study.

A suitable source of dietary carbohydrate is necessary to spare or the use of carbon chains from amino acid for chitin synthesis (Cowey and Forster, 1971). Chitin synthesis is considered to be important for the synthesis of peritropic membrane around the faecal pellets as well as for the exoskelton. The protein sparing action of the carbohydrate in the diet at 30% level was reported by Andrews *et al.* (1972) in *Penaeus aztecus*. A faster growth was also observed on inclusion of 40% corn starch in a casein based diet (Andrews and Sick, 1972). In this investigation, a comparable carbohydrates level (26 -39%) was maintained. The carbohydrates content was attained by the incorporation of the carbohydrate rich wheat flour and tapioca flour in these diets.

A minimum nutrient leaching is essential for the entire time for an effective conversion of the feed which depends on the time it remains in the water. Thus the water stability can only be achieved by using effective binders. The capacity of a binding agent depends on a variety of factors including: feed particle size — binding efficiency and pellet durability decreasing with increasing feed particle size (Hasting, 1971; Viola *et al.*, 1986); manufacturing processes — the binding capacity of starch based feed ingredients increasing with heat treatment and starch gelatinization (Hilton *et al.*, 1981; Murai *et al.*,1981; Hasting, 1971; Viola *et al.*, 1986);. Pellet diameter and die thickness — -binding efficiency increasing with decreasing pellet diameter and increasing die thickness (Viola et al. , 1986). The results of the experiments done for physical evaluation of the formulated diet pellet suggest that present composition of the diet can be used effectively in the formulations of varying sizes of the pellets depending upon the need of the experimental animals. The commonly used binders include agar, sodium alginate, rice powder, wheat powder, mytha powder and tapioca powder of which agar and sodium alginate are considered to be the best but for its high cost compared to others. The comparison of the binding efficiencies of the formulated feeds in this study also has been found to be in tune with the above observations with the highest retention with sodium alginate (95%). Of the low cost binders used in the present investigation tapioca flour presented the highest stability (90%) which is comparable with sodium alginate and agar. The alginates were observed to present a negative effect on the apparent digestibility of nitrogen, fat, ash and calcium and an increase in the moisture content of the faeces (Storebakken, 1985). Earlier studies have recommended the incorporation of tapioca flour in the artificial feeds, as a replacement of the binders of algae origin (agar and alginates) which can act both as a binding agent and as a source of carbohydrate (Ahamed Ali, 1988b; 1990). The economic concern about the artificial diets also points that these carbohydrate rich sources represents highly potential ingredients as it can eliminate the usage of separate binders which can considerably increase the cost of feed.

Shelf life of processing, storage, temperature and moisture content of the diet were reported by Hilton *et al.* (1977) in fish feeds. However, Fowler and Banks, (1967) found no alteration in nutritional status of the pellets stored at room temperature for weeks but storage for greater period had detritus effect on the growth performance of the fishes. But Shivananda Murthy and Devaraj, (1992) reported that when the storage period confined with monsoon season, an increase in moisture content in the artificial diet for carp culture was observed, possibly due to the high atmospheric humidity which prevale in that season. The significantly low variation in the moisture content of the feeds in the present study is indicative of a considerably high shelf life. This has a special significance as the climatic conditions high humidity and comparable temperature can lead to an early deterioration of the quality of any normal feed by the initiation of micro organism induced decay and such a decay was always indicated by an increase in the moisture content. The significantly low variation in the nutritional factors like protein, carbohydrates and lipid also is suggestive of the retainment of the quality of these feeds.

# Chapter IV

# GROWTH RESPONSE

## INTRODUCTION

The two major considerations, one should have in formulating a diet for aquaculture, are (1) the ingredients chosen should satisfy both the nutritional requirements and the economic effectiveness and (2) the formulated feed should have acceptability and digestibility.

Diatoms are the most preferred food during the protozoea stages of the penaeid prawns Artemia nauplii are also used as a food. In the absence of ready- made food, farmers depend on locally available food of low grade prawns and mussels. Particulate suspensions of crustacean tissue made out of cheap and easily available marine crustaceans with a size suitable to the particular larval stages are reported to be excellent feed in prawn culture. It is found that body constituents of clams are almost the same as those of prawns and feeding prawns with clams is reported to give good growth rate.

In course of time natural feed will be scarce and hence artificial feed is a great necessity for promoting prawn culture on a large scale. Now a days artificial dry feed pellets containing essential components are also applied in culture systems. The ingredients of plant origin and essential minerals are properly combined in definite proportions to make suitable feed by utilizing the locally available cheap materials. Normally feed preference differs with species cultured. Feed application is also related to the type of culture practiced.

The supplemental diet is one which contains required amounts of proteins, lipids, carbohydrates, fibers, minerals and vitamins. The requirements of essential amino acid and poly unsaturated fatty acids are very specific for achieving high rates of production. Protein- Energy ratio and growth promoting substances also play an important role in optimal growth. The percentage requirements of these components vary from species to species and also with age within the same species. Larval feeds, grow out feeds and maturation feeds thus differ in their composition.

During the past two decades prawn nutrition received tremendous impetus with active development of aquaculture. As a result enormous literature is now available on dietary requirements of larval nutrition, feed formulation and feed technology (Andrews and Sick, 1972; Zein-Eldin and Meyers, 1973; Colvin,1976; Glude, 1976; Joseph, 1977; AQUACOP, 1978; Bottino *et al*., 1980; Conklin *et al*., 1980; New, 1980; Fenucii *et al*., 1980; Dall and Moriaity, 1983). Kanazawa (1984) brought out the achievements made in penaeid prawn nutrition.

There are reports regarding the preliminary studies on the preparation and feeding of crustacean diets (Deshimaru and Shigueno, 1972; Forster, 1972b, 1976; Deshimaru and Kuroki, 1974; 1975; 1976, 1979; Balazs *et al*., 1973; Brand and Colvin, 1977; Deshimaru and Yone,1978; Goswami and Goswami, 1979,1980; Conklin *et al*., 1980; Rajyalakshmi *et al*., 1982 and Mohamed *et al*., 1980; Ahamed Ali and Mohamed, 1985)

Several workers had directed their effort on developing artificial diets capable of sustaining good growth of prawns. The contributions by Sick *et al*. (1972), Andrews *et al*. (1972), Forster (1972a), Forster and Beard (1973), Zein-Eldin *et al*. (1973, 1976); Balazs *et al*. (1974), Deshimaru and Kuroki (1975), Venkataramiah *et al*. (1975), Balazs and Ross (1976), Colvin (1976), Sandifer *et al*. (1976), Bages and Sloane (1981), Kanazawa *et al*. (1981), Bautista (1986) and Rajyalakshmi (1991) are worth mentioning. Recently purified diets based on casein were also successfully tried by many investigators in nutritional studies on various penaeid prawns (AQUACOP, 1978; Gopal, 1986; Ahamed Ali, 1988a; Civera and Guillaume, 1989; Diminu and Lim, 1989).

The protein requirements for various species of shrimp have also been investigated. A wide range of dietary protein requirement values were reported by the investigators for various species of shrimp and prawns as given in the Table 4.1 This variation may be due to the differences in the species, raw materials and environmental conditions. Several materials have therefore been defined as suitable major sources of protein for shrimp diets. The available informations suggest that a protein level ranging from 30 - 40% will be adequate for different species of prawn (Cherian *et al*., 1991).

Energy production from protein oxidation is both nutritionally and economically wasteful. Thus, it is necessary to spare protein for growth by optimizing the level of non-protein energy sources. A suitable source and an adequate amount of inexpensive carbohydrate in the diet are therefore potentially desirable to improve the protein utilization. There is little information on the carbohydrate nutrition of penaeid prawns (New, 1976; 1980; Kanazawa, 1984). The type and level of carbohydrates in the diet have been shown to effect the growth and survival of *Penaeus japonicus* (Abdel-Rahman *et al*., 1979), *Penaeus aztecus* (Andrews *et al*., 1972) and in *Penaeus duorarum* (Sick and Andrews, 1973). In *Penaeus monodon*, Pascual *et al*. (1983) obtained significant differences between the type and level of carbohydrates in the diet on the survival of juveniles. Alava and Pascual (1987) reported the quantitative and qualitative needs of *Penaeus monodon* juveniles for carbohydrates in semi purified diets and ascertained the effect.

The crustaceans were found to be unable to tolerate high levels of dietary fat (Kitabayashi *et al*., 1971; Andrews *et al*.,

Table 4.1

Dietary protein requirement of prawns (expressed as % of dry diet).

| No | Species | Life stage | Optimum level (%) | Reference |
|---|---|---|---|---|
| 1 | *P. monodon* | Juvenile | 45 | Lee (1971) |
| 2 | " | Postlarva | 30 | Khannapa (1977) |
| 3 | " | Juvenile | 30-40 | Khannapa (1979) |
| 4 | " | Postlarva | 55 | Bages & Sloane (1981) |
| 5 | " | Juvenile | 35 | Lin et al. (1981) |
| 6 | " | Juvenile | 40 | Alava & Lim (1983) |
| 7 | " | Juvenile | 40-50 | Bautista (1986) |
| 8 | " | Juvenile | 55 | Nezaki (1986) |
| 9 | " | Brood stock | 50-55 | Millamena *et al.* (1986) |
| 10 | *P. indicus* | Jevenile | 43 | Colvin (1976) |
| 11 | " | Juvenile | 50-60 | Sambasivam *et al.* (1982) |
| 12 | " | Juvenile | 43 | Ahamed Ali (1982a) |
| 13 | " | Early postlarva | 40 | Bhasker (1982) |
| 14 | " | Late postlarva/ Juvenile | 30 | Bhasker (1982) |
| 15 | " | Juvnile | 35-40 | Gopal (1986) |
| 16 | " | Juvenile | 25 | Ahamed Ali (1988a) |
| 17 | " | Juvenile | 29 | Ahamed Ali (1988a) |
| 18 | *P. merguiensi* | Juvenile | 50-55 | AQUACOP (1978) |
| 19 | " | Juvenile | 34-42 | Sedgwick (1979) |
| 20 | *P. japonicus* | Juvenile | 55 | Kanazawa *et al.* (1970 |
| 21 | " | Juvenile | 54 | Kitabayashi *et al.* (1971) |
| 22 | " | Juvenile | 60 | Deshimaru and Shigueno (1972) |
| 23 | " | Juvenile | 60 | Shigueno *et al.* (1972) |
| 24 | " | Juvenile | 40 | Balazs *et al.* (1973) |
| 25 | " | Juvenile | 50 | Deshimaru & Kuroki (1974) |

Table 4.1 (Contd.)

| No | Species | Life stage | Optimum level (%) | Reference |
|---|---|---|---|---|
| 26 | *P. japonicus* | Juvenile | 52-57 | Deshimaru & Yone (1978) |
| 27 | " | Larva | 45 | Teshima & Kanazawa (1984) |
| 28 | *P. aztecus* | ___ | 23-31 | Shewbart *et al.* (1973) |
| 29 | " | ___ | 40 | Balazs *et al.* (1973) |
| 30 | " | Post larva | 40 | Venkataramiah *et al.* (1975b) |
| 31 | " | Juvenile | 52 | Zein-Eldin & Corliss (1976) |
| 32 | " | Juvenile | 37 | Fenucii & Zein- Eldi (1976) |
| 33 | *P. setiferus* | Juvenile | 28-32 | Andrews *et al.* (1972) |
| 34 | " | ___ | 30 | Fenucci *et al.* (1980) |
| 35 | *P. duorarum* | Juvenile | 28-30 | Sick & Andrews (1973) |
| 36 | *P. stlirorostris* | Postlarva | 30-35 | Colvin & Brand (1977) |
| 37 | " | ___ | 30 | Fenucci *et al.* (1980) |
| 38 | *P. aliforniensis* | Early postlarva | 44 | Colvin & Brand (1977) |
| 39 | " | Late postlarva | 30-35 | Brand & Colvin (1977) |
| 40 | *P. vannamei* | Postlarva | 30-35 | Colvin & Brand (1977) |
| 41 | " | Larva | 38 | Smith & Lawrence (1988) |
| 42 | *M. monoceros* | Juvenile | 55 | Kanazawa *et al.* (1981) |
| 43 | *M. macleayi* | | 27 | Maguire & Hume (1982) |
| 44 | *P. serratus* | ___ | 30-40 | Forster&Beard (1973) |
| 45 | *M. nobili* | Juvenile | 35 | Murugadas & Pandian (1987) |

Table 4.1 (Contd.)

| No | Species | Life stage | Optimum level (%) | Reference |
|---|---|---|---|---|
| 46 | *M. rosenbergii* | Juvenile | 35 | Balazs & Ross (1976) |
| 47 | *M. rosenbergii* | ___ | 25 | Manik (1976) |
| 48 | " | Larva | 15-20 | Sick (1976) |
| 49 | " | Juvenile | 25 | Clifford & Brick (1979) |
| 50 | " | Juvenile | 40 | Millikin *et al.* (1980) |
| 51 | " | Juvenile/ Sub adult | 15 | Boonyaratpalin & New (1982) |
| 52 | " | ___ | 25 | Perry *et al.* (1984) |
| 53 | " | ___ | 14 | Antiporda (1986) |
| 54 | " | Juvenile | 33-35 | D'Abramo & Reed (1988) |
| 55 | " | Juvenile | 13-25 | Gomez *et al.* (1988) |
| 56 | " | Juvenile | 30 | Freuchtenicht *et al.* (1988) |

1972; Forster and Beared, 1973; New, 1976). The suggested optimum level was between 5 to 10%.

Along with the organically bound hydrogen, carbon, nitrogen and oxygen, there are about 20 inorganic elements which are considered to be essential to animal life, including fish and shrimp. The essential mineral elements are usually classified into two main groups according to their concentrations in the animal body; (a) the macroelement which are structural constituents and (b) the micro elements maintain the metabolic function of organisms. Prawn moults at frequent intervals and the shell and carapace require a continuous supply of calcium, phosphorus and other minerals apart from chitin. Mineral metabolism differs from that of other nutrients in that, in contrast to proteins, carbohydrates, fats and vitamins, minerals are neither produced nor consumed by the prawns in bulk. The evaluation of mineral requirement is extremely difficult because of the problems in limiting their concentrations in the diet and also of the water borne contribution to the intake of the minerals.

References to mineral on shrimp nutrition are scarce, although many workers have used mineral supplements in diet meant for shrimps (Table 4.2). These supplements were formulated mainly based on premixes used for other farm experimental animals (New, 1976). Crustaceans have high content of ash (15.9%) in the body. Since sea water is rich in many ions of minerals,the organisms may satisfy most of their mineral requirements from the surrounding environment. The composition of four of the mineral mixetures which have been used in shrimp ration is given in Table 4.3. The Table 4.3 also presents the calculated contributions of these supplements to diets.

The trace metal concentrations in the prawn *Palaemon elegans* with respect to the trace metal concentrations in the surrounding water was studied by White and Rainbow (1982). The importance of copper in crustacea was reviewed by Lontie and

Table 4.2

Composition of some shrimp diet mineral premixes (g \ 100g dry diet)

| Composition | Premix numbers* | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| $K_2HPO_4$ | 2.310 | 0.500 | 1.500 | 0.600 |
| $CaHPO_4 \cdot 2H_2O$ | | | 1.370 | 0.548 |
| $Ca_3(PO_4)2$ | 2.110 | 0.750 | | |
| KCl | 0.724 | | 0.470 | 0.188 |
| $MgSO_4$ | 1.140 | | 0.740 | 0.296 |
| $CaCO_3$ | 1.293 | | 0.840 | 0.336 |
| $C_3H_5O_3$ $2Ca.5H_2O$ | | 3.750 | | |
| $FeCl_3$ | | | 0.070 | 0.028 |
| $FeSO_4 \cdot 7H_2O$ | 0.108 | | | |
| $MnSO_4 \cdot 7H_2O$ | 0.015 | | 0.010 | 0.004 |
| Total premix inclusion in the diet (%) | 7.700 | 5.000 | 5.000 | 2.000 |

* 1. Kanazawa *et.al.* (1972) 2. Deshimaru and Shigueno (1972)
3. Sick *et al.* (1972) 4. Andrews and Sick (1972)

Table 4.3

Mineral contribution to shrimp diets by premixes

| Mineral | Premix number* 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| (g \ 100g dry diet) | | | | | |
| Calcium | 1.336 | 0.679 | 0.655 | 0.264 | |
| Phosphorous | 0.832 | 0.239 | 0.514 | 0.206 | |
| Potassium | 1.417 | 0.244 | 0.919 | 0.368 | |
| Magnesium | 0.230 | | 0.150 | 0.060 | |
| Sodium | | | | | 0.157 |
| Chloride | 0.344 | | 0.270 | 0.107 | 0.243 |
| Sulphate | 0.951 | | 0.594 | 0.237 | |
| (mg\dry diet) | | | | | |
| Iron | 216.60 | | 240.90 | 96.40 | 19.80 |
| Copper | | | | | 2.00 |
| Manganese | 30.50 | | 19.80 | 7.90 | 60.00 |
| Zinc | | | | | 44.10 |
| Cobalt | | | | | 0.20 |
| Iodine | | | | | 1.20 |
| Calcium-Phosphorus Ratio | 1.61 | 2.84 | 1.28 | 1.28 | |

* 1. Kanazawa *et al.* (1970) 2. Deshimura and Shigueno (1972)
3. Sick *et al.* (1972) 4. Andrews and Sick (1972)
5. Balazs *et al.* (1974b)

Vanquickenborne (1974), and the variation in copper in the different part of the body was studied by Stickney *et al.* (1975) in *P. aztecus* and *P. setiferus,* Zingde *et al.* (1976) in *P. monodon* and *M. affinis,* Horowitz and Preseley (1977) in *P. aztecus* and Subash Chander (1986) in *P.indicus*. It was suggested that copper is absorbed by crustaceans from the surrounding water (Byran, 1968; White and Rainbow, 1982; Subash Chander, 1986).

Zinc is an essential component of more than 80 metalloenzymes, including carbonic anhydrase (required for the transport of carbon dioxide by the blood and for the secretion of HCl in the stomach), glutamic dehydrogenase, superoxide dismutase, pancreatic carboxypeptidase, and tryptophan desmolase, thus many metabolic functions are affected by the deficiency of zinc. Many workers reviewed the concentration of zinc in the body of lobster, *Homorusvulgaris* (Byran, 1964), in the crab *Callinactus sapides* (Colvocorresses and Lynch, 1975) in the prawn *P.californiensis* (Byran, 1968), in the *Palaemon elegans* (White and Rainbow, 1984) and in *Penaeus indicus*(Chandran, 1986 and Ahamed Ali, 1988a). All have reported varying results. Their studies indicated that zinc was absorbed to some extent by these animals from the surrounding medium.

Determination of food intake, growth and conversion efficiency are known to be the best indices to evaluate the growth of organisms. Thus laboratory studies on growth and conversion efficiency of decapod crustaceans were useful in promoting crustacean culture (Katre and Reddy, 1977). Several workers have directed their effects on the evaluation of the growth, survivalassimilation and food conversion efficiencies of various species of prawns using the artificial diets (Karim and Aldrich, 1970 on *P.aztecus* and *P. setiferus*; Condrey, 1971 Grajcer and Neal, 1972 on *P.aztecus*; Kittaka, 1976 and Knight, 1976 on *Macrobrachium rosenbergii* and Sedgwick, 1979, on *Penaeus. merguiensis*; Brisson and Pace,1978 and Forster, 1976, on *Palaemon serratus*; Katre and Reddy, 1977 on *Palaemon lamarrei*; Pascual *et al.*, 1983 on *Penaeus. Monondon*; Sambasivam *et al.*, 1982 on *Penaeus indicus*). Since the work of Subrahmanyan and Oppenheimer (1969), numerous studies have been reported on the growth rates and feed efficiencies of various crustaceans fed on different levels of dietary protein. (Kanazawa *et al.*, 1970; Deshimaru and Shigueno, 1972).

So far the efficiency of a diet was monitored only through survival rate, increase in body length and weight. It was suggested that biochemical analysis of tail meat should be done regularly so as to manipulate the feeding regime and composition to maximise the protein content of shrimp and shrimp product (Hanson and Goodwin, 1977). Similarly for several nutrient concentrations, metabolites in different tissues would reflect utilization of specific nutrients in the animal (Cowey and Forster, 1971; Gatling and Wilson, 1985). Such an approach would provide an insight on the interaction between different nutrients and also provide valuable information in assessing the nutritional status for an organism.

In the present study the formulated and standard diet were fed to various size groups of juveniles of prawns in the laboratory, paddy field, and esturine shrimp ponds. In the laboratory the low density and high density cultures were also performed. The percentage survival growth and food conversion ratios were simutaneously recorded. The results of preliminary investigation to assess the suitability of the prepared diet as shrimp diet for future experiments were given and discussed. The experiments were designed to assess the relationship between dietary protein and growth in juvenile prawns. The nutritional quality of protein and meal combinations werefurther tested in assimilation studies. The trace metal content in the diet with their various concentration were also analysed.

The aim of the present study was to develop a feeding regime which would stimulate maximum growth rate with efficient food conversion in juvenile prawns fed with an artificial diet in a culture station.

MATERILAS AND METHODS.

Acclimation of animals and experimental procedures have been detailed in CHAPTER II.

RESULTS

A two stage evaluation procedure was adopted to critically examine the efficiencies of the formulated feeds with respect to acceptability, growth rate and percentage of survival. In the first phase laboratory culture experiments (both low density and high density) with *Penaeus indicus, Penaeus monodon, Metapenaeus dobsoni*,were conducted. On the basis of evaluation of the efficiency parameters, three of the five formulated feeds were selected for the second phase of the study. In this, high density mass cultures, with a mixed seed were done in the estuarine ponds and paddy fields.

Low Density Laboratory Experiments

The growth of the three species of prawns studied with respect to weight for 90 days feeding experiments for the formulated feeds and the standard are given in the Table 4.4. All the formulated feeds exhibited a comparable growth in all the three species of prawns. The standard feed always presented a better growth. The period of culture was divided into three phases of 30 days duration each, the period of each phase being 0-30 days, second 30- 60 days, and the third 60-90 days. The percentage of growth, taking the growth rate of standard as the base,was found to be the highest (86.4%) with the feed PD4 among the formulated feeds for *Penaeus indicus* in the first phase of the experiment followed by PD2 (84.9%) and the lowest contribution was given by PD1 (75.09%). In the second phase of the experiment the percentage growth was highest for PD1 (121.7%) followed by PD5 (121%) and lowest was observed with PD4(85.40%). In the third phase the order of percentage growth was PD5 (90.90%) > PD4 (87.19%) > PD3 (83.1%) > PD2 (83.05%) > PD1 (79.75%).

For *Penaeus monodon* in the first phase PD2 gave highest value (90.2%) for percentage of growth and the lowest(62.6%) by PD3. In the second phase PD5 gave highest percentage(121.4%) of growth followed by PD3 (120.1%) and in the third phase the order was PD1 >PD2 >PD3 > PD4 >PD5.

In the case of *Metapenaeus dobsoni* the percentage of growth compared to standard was in the order, PD2 (90.24%) > PD1 (88.2%) > PD3 (74.39%) > PD5 (73.1%) > PD4 (70.3%) for first phase of the experiment.Where as in the second phase the highest value of growth was for PD4 (104.3%) and lowest for PD5 (91.20%) and in the final phase PD5 (178.3%) recorded highest value followed by PD4(144.4%) and the lowest for PD2 (100%).

The efficiency of the feeds in terms of percentage survival, FCR and acceptability for the three species of prawns are given in the Table 4.5. In all three phases of growth, PD2 gave the maximum survival for all the three species. The values were (97.2, 92.5, 90.1), for *Penaeus indicus*, (95.4, 93.2, 90.1) for *Penaeus monodon* and (93.2, 90.5, 89.7) for *M.dobsoni* during the I, II, and III phase respectively. The lowest percentage survival was given by standard in all the cases. Among the formulated feeds the lowest percentage survival in all three phases was given by PD5 for *P.indicus* and *P.monodon* and PD4 for *M. dobsoni*.

The feed efficiency values in terms of food conversion ratio for the three species of prawn in the three phases of growth showed that the formulated feeds was more efficient than standard FCR in terms of FCR values.

The acceptability of feeds for the 90 day period for *P. indicus* were in the order PD2 (81.9%) > STD (76.17%) > PD1 (74.76%) > PD3 (72.72%) > PD4 (69.2%) > PD5 (65.4%) and for P

Table 4.5
Efficiency of the feeds

a) Penaeus indicus

| Feeds | 30 day | | | | | 60 day | | | | | 90 day | | | | | Acceptability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Increase in wt(g) | Food Consumed (g) | FCR | Daily Growth Rate | Percentage Survival | Increase in wt (g) | Food Consumed (g) | FCR | Daily Growth Rate | Percentage Survival | Increase in wt (g) | Food Consumed (g) | FCR | Daily Growth Rate | Percentage Survival | |
| STD | 2.65 | 13.60 | 5.13 | 7.50 | 89.00 | 1.38 | 7.27 | 5.21 | 1.24 | 81.00 | 2.42 | 12.12 | 5.01 | 1.47 | 74 | 76.17 |
| PD1 | 1.99 | 9.10 | 4.57 | 6.80 | 90.40 | 1.68 | 7.56 | 4.50 | 1.80 | 85.2 | 1.93 | 7.91 | 4.18 | 1.3 | 82 | 81.9 |
| PD2 | 2.25 | 7.50 | 3.33 | 7.20 | 97.20 | 1.65 | 5.14 | 3.12 | 1.60 | 92.5 | 2.01 | 6.05 | 3.01 | 1.4 | 90.1 | 74.76 |
| PD3 | 2.00 | 6.90 | 3.45 | 6.46 | 94.10 | 1.51 | 4.53 | 3.00 | 1.60 | 90.2 | 2.11 | 6.75 | 3.20 | 1.46 | 89.7 | 72.72 |
| PD4 | 2.29 | 6.70 | 2.90 | 7.30 | 90.30 | 1.18 | 4.20 | 3.55 | 1.20 | 85.7 | 2.2 | 6.4 | 2.90 | 1.43 | 82.1 | 69.2 |
| PD5 | 2.01 | 6.20 | 3.08 | 6.74 | 89.70 | 1.67 | 5.70 | 3.43 | 1.80 | 82.7 | 1.66 | 6.4 | 3.85 | 1.1 | 80.5 | 65.4 |

Table 4.5 Contd......

Table 4.5 Contd......

b) *Penaeus monodon*

| Feeds | 30 day | | | | | 60 day | | | | | 90 day | | | | | Acceptability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Increase in wt(g) | Food Consumed (g) | FCR | Daily Growth Rate | Percentage Survival | Increase in wt (g) | Food Consumed (g) | FCR | Daily Growth Rate | Percentage Survival | Increase in wt (g) | Food Consumed (g) | FCR | Daily Growth Rate | Percentage Survival | |
| STD | 2.46 | 12.5 | 5.08 | 8.60 | 87.00 | 3.34 | 15.36 | 4.59 | 3.20 | 78.00 | 2.70 | 14.04 | 5.20 | 1.20 | 73.00 | 83.00 |
| PD1 | 2.21 | 9.60 | 4.34 | 8.40 | 92.00 | 2.85 | 9.40 | 3.24 | 2.60 | 90.00 | 1.97 | 8.47 | 4.23 | 1.06 | 87.00 | 91.50 |
| PD2 | 2.22 | 7.10 | 3.19 | 8.60 | 95.40 | 3.57 | 8.90 | 2.49 | 3.06 | 93.20 | 1.42 | 4.27 | 3.07 | 0.90 | 90.10 | 86.80 |
| PD3 | 1.54 | 6.10 | 3.96 | 7.40 | 93.20 | 4.04 | 10.10 | 2.50 | 4.00 | 90.20 | 1.19 | 4.64 | 3.86 | 0.80 | 85.70 | 84.88 |
| PD4 | 1.67 | 6.30 | 3.77 | 7.90 | 93.00 | 3.61 | 10.53 | 2.91 | 3.60 | 89.00 | 1.12 | 4.39 | 3.92 | 0.60 | 85.00 | 88.68 |
| PD5 | 1.61 | 5.90 | 3.68 | 6.90 | 90.40 | 4.05 | 12.06 | 2.97 | 3.90 | 88.70 | 1.06 | 4.21 | 3.96 | 0.55 | 81.20 | 85.40 |

Table 4.5 Contd......

Table 4.5 Contd......

c) *Metapenaeus dobsoni*

| Feeds | 30 day | | | | | 60 day | | | | | 90 day | | | | | Acceptability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Increase in wt(g) | Food Consumed (g) | FCR | Daily Growth Rate | Percentage Survival | Increase in wt (g) | Food Consumed (g) | FCR | Daily Growth Rate | Percentage Survival | Increase in wt (g) | Food Consumed (g) | FCR | Daily Growth Rate | Percentage Survival | |
| STD | 2.56 | 13.20 | 5.36 | 6.50 | 85.20 | 2.75 | 14.02 | 5.09 | 2.20 | 81.20 | 1.80 | 9.36 | 5.20 | 0.90 | 81.20 | 81.20 |
| PD1 | 2.17 | 7.30 | 3.36 | 6.10 | 90.00 | 2.61 | 10.46 | 4.07 | 2.30 | 87.00 | 1.82 | 7.46 | 4.11 | 1.00 | 84.00 | 84.00 |
| PD2 | 2.22 | 6.40 | 2.88 | 6.30 | 93.20 | 2.77 | 9.48 | 3.42 | 2.01 | 90.50 | 1.80 | 5.04 | 2.80 | 0.91 | 83.60 | 83.60 |
| PD3 | 1.83 | 6.70 | 3.66 | 5.90 | 91.80 | 2.79 | 8.65 | 3.09 | 2.75 | 89.40 | 2.57 | 8.61 | 3.35 | 0.95 | 79.80 | 79.80 |
| PD4 | 1.73 | 6.90 | 3.90 | 5.80 | 90.70 | 2.87 | 10.33 | 3.70 | 2.80 | 85.30 | 2.60 | 8.70 | 3.38 | 1.40 | 74.08 | 74.08 |
| PD5 | 1.80 | 7.56 | 4.20 | 5.70 | 90.70 | 2.51 | 9.70 | 3.18 | 2.50 | 87.20 | 3.21 | 10.22 | 3.18 | 1.70 | 78.50 | 78.50 |

monodon the order was PD1 > PD4 > PD2 > PD3 > PD5 > STD and for *Meta penaeus dobsoni* the order was PD1 > PD2 > STD > PD3 > PD5 > PD4.

The daily growth rate of three species of prawn are given in the Table 4.6. The result showed that daily growth rate varied with growth step of the prawns. When prawns were small in size (first phase of the experiments) the growth rate was higher for all three species, *P.indicus, P. monodon and M. dobsoni* with the standard feed. The values for first phase were 7.5, 8.6 and 6.5; for second phase the values were 1.27, 3.2 and 2.2 and for third phase the values were 1.4 , 1.2 and 0.9 respectively for the same diet in the same order of species of prawns. Among the formulated diets, in the first phase PD4 gave the highest growth rate (7.3), PD1 and PD5 (1.8) in the second phase and PD2 (1.46) in the third phase for *P.indicus*. In the case of *P.* monodon PD2 presented maximum value in first phase (8.6) followed by PD3 in second phase (4.0) and in third phase PD1 gave the maximum value (1.06). With *M.* dobsoni PD2 gave the highest value (6.3) in the first phase, PD4 (2.8) in the second phase and PD5 (1.7)in the third phase.

The results of conversion efficiency of the formulated and standard feeds are given in the Table 4.7. The PD2 exhibited assimilation efficiency, which is comparable with the standard for all the three species 94.6 and 94.5 for *P. indicus*, and 93.94 and 95.06. for *P. monodon* and 94.3 and 94.5 for *M.dobsoni*, for PD4. and standard respectively. A very low assimilation efficiency was observed with PD2 and PD5 for *P. indicus* (84.05, 86.05). The gross and net conversion efficiencies were found to be maximum with PD2 in the case of *M.dobsoni* and *P.monodon*, but PD4 gave the highest values for *P. indicus*. In all the cases standard was found to have considerably low conversion efficiencies. The order of efficiency for the three species were i). PD4 > PD5 > PD2 >PD3 >PD1 > STD for gross conversion and PD5 > PD4 > PD3 >PD2 > PD1 > STD for net conversion efficiencies for *P. indicus* ii). PD2 > PD5 > PD4 > PD3 > PD1 >

Table 4.6

Daily growth rate of prawns

| Prawn Species | Days | Feed used | | | | | |
|---|---|---|---|---|---|---|---|
| | | STD | PD1 | PD2 | PD3 | PD4 | PD5 |
| *P.indicus* | 30 | 7.5 | 6.8 | 7.2 | 6.4 | 7.3 | 6.7 |
| | 60 | 1.3 | 1.8 | 1.6 | 1.6 | 1.2 | 1.8 |
| | 90 | 1.5 | 1.3 | 1.4 | 1.5 | 1.4 | 1.1 |
| *P.monodon* | 30 | 8.6 | 8.4 | 8.6 | 7.4 | 7.9 | 6.9 |
| | 60 | 3.2 | 2.6 | 3.1 | 4.0 | 3.6 | 3.9 |
| | 90 | 1.2 | 1.1 | 0.9 | 0.8 | 0.6 | 0.5 |
| *M.dobsoni* | 30 | 6.5 | 6.1 | 6.3 | 5.9 | 5.8 | 5.7 |
| | 60 | 2.2 | 2.3 | 2.0 | 2.7 | 2.8 | 2.5 |
| | 90 | 0.9 | 1.0 | 0.9 | 0.9 | 1.4 | 1.7 |

Table 4.7
Conversion Efficiency of the feeds(30 days)

| Feeds | Consumption (g) C | Faeces (g) F | Production (g) P | Assimilation efficiency (%) A = C-F/C | Gross Conversion Efficiency P/C (%) | Net Conversion efficiency P/A (%) |
|---|---|---|---|---|---|---|
| a) P.indicus | | | | | | |
| STD | 13.6 | 0.74 | 2.65 | 94.5 | 19.4 | 20.60 |
| PD1 | 9.1 | 0.53 | 1.99 | 94.1 | 21.8 | 23.21 |
| PD2 | 7.5 | 0.40 | 2.25 | 94.6 | 30.0 | 31.6 |
| PD3 | 6.9 | 0.60 | 2.00 | 91.30 | 28.98 | 31.74 |
| PD4 | 6.7 | 0.90 | 2.29 | 84.05 | 34.17 | 39.48 |
| PD5 | 6.2 | 0.82 | 2.04 | 86.05 | 32.90 | 37.41 |
| b) P. monodon | | | | | | |
| STD | 12.5 | 0.62 | 2.46 | 95.06 | 19.68 | 20.70 |
| PD1 | 9.6 | 0.51 | 2.21 | 94.68 | 23.02 | 24.31 |
| PD2 | 7.1 | 0.43 | 2.22 | 93.94 | 31.26 | 33.28 |
| PD3 | 6.1 | 0.42 | 1.54 | 93.11 | 25.24 | 27.11 |
| PD4 | 6.3 | 0.39 | 1.67 | 93.80 | 26.50 | 28.25 |
| PD5 | 5.9 | 0.37 | 1.61 | 93.72 | 27.28 | 29.11 |
| c) M. dobsoni | | | | | | |
| STD | 13.2 | 0.72 | 2.46 | 94.54 | 18.08 | 21.23 |
| PD1 | 7.3 | 0.41 | 2.17 | 94.38 | 29.72 | 31.75 |
| PD2 | 6.4 | 0.35 | 2.22 | 94.53 | 34.68 | 36.69 |
| PD3 | 6.7 | 0.42 | 1.83 | 93.73 | 27.31 | 29.14 |
| PD4 | 6.9 | 0.51 | 1.73 | 92.60 | 25.07 | 27.04 |
| PD5 | 7.6 | 0.32 | 1.80 | 95.70 | 23.80 | 31.25 |

STD for gross conversion and PD2 > PD5 > PD4 > PD3 > PD1 > STD for net conversion efficiencies for *P.monodon*. iii). PD2 > PD1> PD3 > PD4 > PD5 > STD for gross conversion and PD2 > PD1 > PD5 > PD3 > PD4 > STD for net conversion efficiencies for M.dobsoni.

The dietary concentrations of the essential metal copper, zinc and manganese in the formulated, standard and in the prawns are given Table 4.8, and the effect of addition of metals to the feeds on the growth response are given in the Table 4.9 and Fig.4.1. Dietary copper content of the standard, the formulated feeds were 2.4mg/100g 2.6mg/100g and in tissue 29.60mg respectively. On increasing the copper concentration, the tissue protein level is increased from 61.92 to 67.12 % for standard and 71.05 to 78.12% in formulated feed. The efficiency of the feed was found to be decreasing with an increase in the dietary copper content for both the feeds. For standard,the value increased from 4.8 to 5.9 and for formulated feed 2.9 to 4.1. The percentage survival was decreased from 89 to 72% for standard and from 97 to 81% for formulated diet on increasing the copper concentrations.

Concentration of zinc in the standard,the formulated feed and in the prawn were 5.9mg/100g and 4.7mg/100g,and 36.7 mg/100g respectively. On increasing zinc concentration,the tissue protein level is increased from 61.92 to 68.14% in standard and71.05 to 78.03% for formulated feed. The dietary zinc content present in the feeds showed better growth response than the feeds with added zinc concentration. The feed efficiency such as percentage of survival decreased from 89 to 67% and 97 to 73% respectively for standard and formulated feeds. The fcr also decreased from 4.7 to 4.6 and 2.9 to 2.7 in the same order of feeds

The manganese concentration of standard, formulated feed and in the prawns were 0.24 mg/100g and 0.19mg/100g and 0.29mg/100g respectively. On increasing the manganese concertration, the tissue protein value decreased from 61.90 to 58.50% and from

Table 4.8
Concentration of Metals in feeds and Prawns(ppm)

| Items | Cu | Zn | Mn |
|---|---|---|---|
| STD | 2.4 | 5.9 | 0.24 |
| PD1 | 2.2 | 4.2 | 0.22 |
| PD2 | 2.6 | 4.7 | 0.21 |
| PD3 | 1.8 | 4.8 | 0.19 |
| PD4 | 2.0 | 4.6 | 0.20 |
| PD5 | 2.2 | 4.1 | 0.21 |
| Prawn | 29.9 | 36.7 | 0.29 |

Table 4.9 Growth response in presence of added metals

| No | Name of the feed | metals | Conc of the metal dosed (ppm) | Conc of the metal observed in the feed (ppm) | Conc of the metal observed in the prawn (ppm) | Tissue protein (percentage) | FCR | Percentage survival |
|---|---|---|---|---|---|---|---|---|
| 1 | standard | Cu | 0 | 2.40 | 29.60 | 61.92 | 4.8 | 89 |
| | | | 0 | 3.10 | 29.90 | 65.11 | 5.1 | 83 |
| | | | 0.010 | 4.70 | 30.07 | 66.22 | 5.4 | 81 |
| | | | 0.050 | 5.80 | 30.10 | 66.52 | 5.6 | 78 |
| | | | 0.100 | 17.01 | 31.20 | 67.12 | 5.9 | 72 |
| 2 | formulated | Cu | 0 | 2.60 | 29.60 | 71.05 | 2.9 | 97 |
| | | | 0.005 | 3.70 | 30.00 | 73.02 | 3.1 | 94 |
| | | | 0.010 | 4.90 | 31.10 | 75.66 | 3.4 | 90 |
| | | | 0.050 | 6.30 | 32.20 | 77.12 | 3.8 | 89 |
| | | | 0.100 | 18.02 | 33.40 | 78.12 | 4.1 | 81 |
| 3 | standard | Zn | 0 | 5.9 | 36.4 | 61.92 | 4.7 | 89 |
| | | | 0.020 | 12.9 | 36.3 | 65.22 | 4.8 | 85 |
| | | | 0.050 | 15.4 | 36.1 | 66.12 | 4.7 | 79 |
| | | | 0.080 | 24.3 | 35.9 | 67.22 | 4.8 | 71 |
| | | | 0.100 | 30.6 | 34.3 | 68.14 | 4.6 | 67 |
| 4 | formulated | Zn | 0 | 4.7 | 36.7 | 71.05 | 2.9 | 97 |
| | | | 0.020 | 13.2 | 34.5 | 76.02 | 2.7 | 92 |
| | | | 0.050 | 17.5 | 31.4 | 77.34 | 2.7 | 88 |
| | | | 0.080 | 26.3 | 33.8 | 77.47 | 2.6 | 76 |
| | | | 0.100 | 32.4 | 33.0 | 78.03 | 2.7 | 73 |
| 5 | standard | Mn | 0 | 0.24 | 0.29 | 61.92 | 4.8 | 87 |
| | | | 0.002 | 0.57 | 0.31 | 60.25 | 4.7 | 85 |
| | | | 0.003 | 0.89 | 0.32 | 59.77 | 4.7 | 78 |
| | | | 0.004 | 0.99 | 0.44 | 59.27 | 4.3 | 73 |
| | | | 0.005 | 1.40 | 0.63 | 58.50 | 4.3 | 69 |
| 6 | formulated | Mn | 0 | 0.19 | 0.29 | 71.05 | 2.9 | 95 |
| | | | 0.002 | 0.54 | 0.30 | 69.80 | 2.7 | 93 |
| | | | 0.003 | 0.82 | 0.32 | 68.52 | 2.7 | 89 |
| | | | 0.004 | 0.97 | 0.42 | 68.30 | 2.7 | 84 |
| | | | 0.005 | 1.30 | 0.55 | 67.50 | 2.6 | 80 |

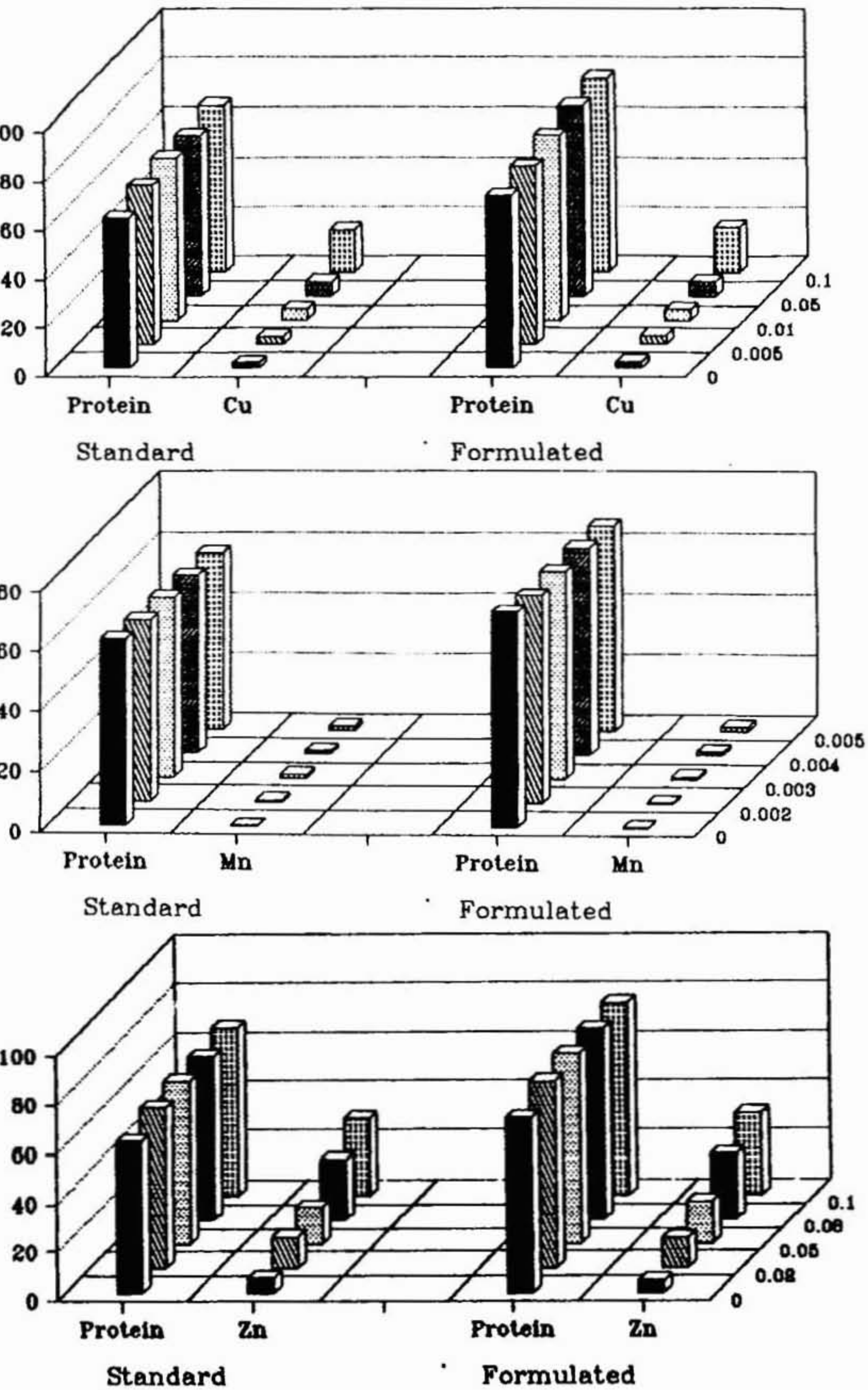


Fig.4.1 Growth response of the prawns when fed with feed containing different concentrations of the metals

71.05 to 67.50% for formulated feeds. The FCR decreased from 4.8 to 4.3 for standard and 2.9 to 2.6 for formulated feeds. The percentage survival decreased from 87 to 69% and 95 to 80% for formulated feeds and the standard feeds respectively.

### High Density Laboratory Experiments

The results of the high density rearing experiments in laboratory with formulated and standard feeds for the three species of prawn are given in the Table 4.10. The relative percentage of growth compared to standard were i). PD1 > PD4 >PD2 > PD5 > PD3 for first phase.ii). PD2 > PD1 > PD3 > PD4 > PD5 for second phase and iii). PD4 > PD5 > PD3 > PD2 > PD1 for third phase for *P. indicus* and PD2 > PD3 > PD1 > PD4 > PD5, PD3> PD5 > PD4 > PD2 > PD1, PD1 > PD2 > PD3 >PD4 >PD5 for first second and third phase for *P. monodon* and for *M. dobsoni* PD2 > PD4 > PD5 > PD3 > PD1 for first phase, PD1 > PD5 > PD3 > PD4 > PD2 for second phase and PD2 > PD3 > PD4 > PD5 > PD1 for third phase.

The overall FCR for all three species were found to be the least with PD2 followed by PD1, PD3,PD4,PD5 and standard. The value of FCR for the first phase and second phase of the growth of *P.indicus* (30, 60 days) were the least with PD4 (2.8, 2.7) and in third phase with PD2 and PD3 (2.7). In all the three phases standard showed the highest FCR (5.3). The FCR during all the three phases were found to be the lowest with PD2 in the case of *M.dobsoni* and *P.monodon* (2.8 and 2.9). The PD2 was followed by PD4, PD3, PD5, PD1 and standard. The percentage survival for all the three species was found to be maximum with PD2. The standard always exhibited a very low value for the percentage survival. PD4 and PD5 recorded a value lower than 90%.

### Field Experiments

The selected feeds and the standard feed were used in prawn

Table 4.10
Growth response of prawns with feeds (High density culture)
a) P.indicus

| Feeds | Initial wt of prawn (g) | 30day | | | | 60day | | | | 90day | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Final wt of prawn (g) | % wt * | Efficiency | | wt(g) | % wt * | Efficiency | | wt (g) | % wt * | Efficiency | |
| | | | | FCR | %survival | | | FCR | %survival | | | FCR | %survival |
| STD | 0.31 | 3.01 | | 5.2 | 89.00 | 5.53 | | 5.4 | 85.00 | 7.90 | | 4.9 | 80.00 |
| PD1 | 0.27 | 3.10 | 105.50 | 4.2 | 92.00 | 5.52 | 98.03 | 4.5 | 90.00 | 7.04 | 103.40 | 4.4 | 90.00 |
| PD2 | 0.30 | 2.99 | 100.00 | 3.2 | 97.50 | 5.42 | 96.40 | 2.9 | 95.00 | 7.21 | 121.00 | 2.7 | 93.00 |
| PD3 | 0.26 | 2.37 | 78.40 | 3.3 | 95.00 | 4.47 | 83.30 | 3.0 | 93.00 | 6.57 | 142.80 | 2.7 | 92.00 |
| PD4 | 0.23 | 2.99 | 102.60 | 2.8 | 90.00 | 4.12 | 74.84 | 2.7 | 90.00 | 6.03 | 129.93 | 3.4 | 80.70 |
| PD5 | 0.26 | 2.87 | 97.02 | 3.1 | 90.00 | 4.21 | 75.17 | 3.9 | 89.40 | 6.23 | 137.00 | 4.1 | 85.40 |

b) P.monodon

| Feeds | Initial wt of prawn (g) | 30day Final wt of prawn (g) | % wt * | FCR | %survival | 60day wt(g) | % wt * | FCR | %survival | 90day wt (g) | % wt * | FCR | %survival |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STD | 0.20 | 2.99 | | 4.9 | 89.00 | 6.22 | | 5.2 | 87.00 | 8.22 | | 5.3 | 85.00 |
| PD1 | 0.23 | 2.82 | 92.80 | 4.3 | 93.00 | 6.01 | 98.76 | 4.2 | 92.00 | 7.99 | 99.00 | 4.5 | 90.00 |
| PD2 | 0.20 | 2.91 | 97.10 | 2.9 | 98.00 | 6.12 | 99.38 | 3.1 | 94.00 | 7.99 | 93.50 | 2.9 | 91.00 |
| PD3 | 0.24 | 2.85 | 93.54 | 3.6 | 95.00 | 6.17 | 102.78 | 3.5 | 95.00 | 8.01 | 92.00 | 3.2 | 92.00 |
| PD4 | 0.22 | 2.79 | 92.10 | 3.4 | 90.00 | 6.07 | 101.50 | 3.4 | 87.00 | 7.89 | 91.00 | 3.5 | 85.00 |
| PD5 | 0.23 | 2.57 | 83.80 | 3.6 | 89.00 | 6.03 | 107.10 | 3.7 | 84.00 | 7.73 | 85.00 | 3.9 | 82.00 |

c) M.dobsoni

| Feeds | Initial wt of prawn (g) | 30day Final wt of prawn (g) | % wt * | FCR | %survival | 60day wt(g) | % wt * | FCR | %survival | 90day wt (g) | % wt * | FCR | %survival |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STD | 0.47 | 3.56 | | 5.4 | 87.0 | 5.01 | | 5.1 | 82.00 | 7.97 | | 5.2 | 80.00 |
| PD1 | 0.45 | 3.11 | 86.08 | 4.1 | 92.0 | 4.97 | 128.20 | 4.4 | 90.00 | 7.02 | 69.20 | 4.5 | 88.00 |
| PD2 | 0.44 | 3.42 | 96.40 | 2.8 | 97.0 | 4.99 | 108.20 | 2.9 | 93.00 | 7.27 | 77.02 | 2.7 | 90.00 |
| PD3 | 0.41 | 3.21 | 87.70 | 3.4 | 93.0 | 4.89 | 115.60 | 3.6 | 90.00 | 7.04 | 72.60 | 3.7 | 90.00 |
| PD4 | 0.39 | 3.19 | 90.61 | 3.01 | 89.0 | 4.79 | 110.30 | 3.2 | 85.00 | 6.99 | 72.60 | 3.1 | 83.00 |
| PD5 | 0.42 | 3.17 | 88.99 | 3.4 | 87.8 | 4.97 | 124.00 | 3.6 | 86.40 | 6.92 | 74.30 | 3.9 | 82.00 |

* - compared to standard

culture in the paddy fields and in the esturine fish ponds. The results were given in the Table 4.11. In the paddy fields, PD2 gave a production level which is comparable to that obtained with the standard diet followed by PD1 and PD3. PD2 recorded the lowest FCR (2.74). In the fish pond, PD3 gave a production level which is comparable to that obtained with the standard followed by PD1 and PD2. The lowest FCR was recorded by PD2, followed by standard PD1 and PD3.

## DISCUSSION

The evaluation of efficiency of formulated diet is generally carried out by estimating the growth rate and feed conversion ratio. Data on food conversion ratios of various penaeid prawns in response to various dietary formulations have been investigated by Andrews *et al.* (1972); Venkataramiah *et al.* (1975b) and Royan *et al.* (1977), AQUACOP, (1978), Fenucci *et al.*(1980), Goswami and Goswami (1980), Alava and Lim (1983), Gopal (1986), Ahamed Ali and Mohamed (1985) and Jaenike (1989). A generalisation cannot be evolved from results reported in these studies due to the differences in composition of diets, species, size of the animals and other environmental parameters (Kinne, 1960; Hysmith *et al.*,1972; De Silva and Perera, 1976; New 1976; Condrey, 1982; Goswami and Goswami, 1980; De Silva, 1989).

In a mass culture normally one encounters with a mixture of species of prawns in varying growth stages. This makes it essential to have the investigations for evaluation of the efficiencies of feeds independently done with different species of prawn that will be present in the culture to finalise the feasibility of the feeds for rearing of prawns. The species that are generally present in the aquaculture farms of Kerala are *Metapenaeus dobsoni, P.indicus, P. monodon and Macrobrachium rosenbergii*. The *Macrobrachium rosenbergii,* is well known as giant prawn, is not included in this study mainly due to the large size and non availability of seeds at all the seasons.

Table 4.11 Field culture

a) In esturine fish pond (90 days)

| Code No. of Feed used | PD1 | PD2 | PD3 | Standard |
|---|---|---|---|---|
| Initial weight of Prawn | 0.350 | 0.335 | 0.377 | 0.348 |
| Final weight at harvest | 9.61 | 10.73 | 9.737 | 12.862 |
| Increase in weight | 9.26 | 10.438 | 9.36 | 12.514 |
| Total feed given | 35.37 | 30.276 | 39.31 | 40.57 |
| Feed conversion Value | 3.82 | 2.9 | 4.2 | 3.2 |
| * Cost efficeincy ratio | 33.30 | 25.31 | 36.65 | |
| ** Productivity ratio % | 73.99 | 83.41 | 74.79 | |
| Cost of feed per kg of prawn produced | 13.55 | 10.30 | 14.91 | 40.63 |

a) In Paddy field (90 days)

| Code No. of Feed used | PD1 | PD2 | PD3 | Standard |
|---|---|---|---|---|
| Initial weight of Prawn | 0.660 | 0..552 | 0.573 | 0.527 |
| Final weight at harvest | 17.91 | 19.91 | 17.523 | 20.832 |
| Increase in weight | 17.25 | 19.35 | 16.95 | 20.305 |
| Total feed given | 65.55 | 52.24 | 70.1 | 80.3 |
| Feed conversion Value | 3.8 | 2.74 | 4.13 | 3.95 |
| * Cost efficiecny ratio | 27.26 | 19.30 | 29.58 | |
| ** Productivity ratio | 84.76 | 95.39 | 83.34 | |
| Cost of feed per Kg of prawn produced | 13.48 | 9.58 | 14.68 | 49.63 |

* - Cost efficiency ratio = $\frac{\text{cost of feed for 1kg of PD1}}{\text{cost of feed resuced for 1kg with Std}}$

** - Productivity ratio = $\frac{\text{increase in wt for PD1}}{\text{increase in wt for Std}} \times 100$

Under specified conditions, the growth maxima generally depend on the range of dietary protein concentration and an improvement in growth and food conversion is expected from the low to high protein levels in the range. The observed higher growth rate in the case of the standard feed for all the three phases of growth in this study may have been the result of the effect of hormones, that is present in the feed. The high food conversion ratio, the low percentage survival and the low gross and net conversion efficiency values also confirms the role of hormones in the growth with the standard feed. Earlier works also suggests such an increased growth when the feed contains hormones (Fagerland and MC bridge, 1975; Yamazaki, 1976; Matty and Cheema, 1978; Yu *et al.*, 1979; Matty, 1986; Pillai *et al.*, 1987). The significantly high growth rate presented by the formulated feeds (72 to 91.7%) with respect to the standard even in the absence of growth inducing hormones, suggest that the percentage of protein in the diets (30 to 43%) represents an optimum range.

A review of the literature indicated an optimum protein level of 30-45% for shrimp culture (Table 4.1). The effect of substitution of dietary protein of animal origin with that of plant origin was studied, by gradually replacing the former by latter in formulated diets. An improved feed conversion efficiency and other growth parameters for the young shrimp were reported by Balaz and Ross (1976). In the present study the feeds were with 50% protein of animal origin and 50% of plant origin. The high growth rate observed with the formulated feeds in this study may have resulted from the application of this combination of proteins . The low food conversion ratio compared to the standard for all the three species of prawns studied are indicative of a better utilisation of the feed consumed by the prawns.

In penaeid shrimps employing various compounded feeds based on varying protein sources and experimental conditions varying food conversion values were reported (Vekitaramiah *et al.*, 1975b; Royan *et al.*, 1977; Rajyalakshmi *et al.*, 1979; Ahamed Ali, 1982a, 1988a; Goswami and Goswami, 1980; Raman *et al.*, 1982; Sultan *et al.*,1982; Liu and Manceho, 1983; Ahamed Ali and Mohamed, 1985; Gopal, 1986; Hajra *et al.*, 1986; Dominy and Ako, 1988). Because of difference in the dietary formulations,a direct comparison of the food conversion efficiencies obtained in the present experiment with those obtained for the penaeid shrimps in the earlier works is not possible. Stern *et al.* (1976) reported that addition of vegetable matter to the food improved the food conversion efficiency as well as the survival rate of young shrimp. Balazs (1974) and Balazs and Ross (1976) used multi- protein diet containing plant and animal proteins and described them as good growth promoters. Venkataramiah *et al.* (1975) reported that the presence of vegetable matter enhanced the food conversion ratio in the diet of *Penaeus* aztecus.The high percentage of survival observed may be the result of the addition of vegetable matter to the feed. Generally the compounded feeds exhibit a high survival rate (Venkaitaramiah *et al.*,1975b and Royan *et al.*,1977).

Gross($K_1$) and net ($K_2$) growth efficiencies are two other important parameters which can enlighten the effectiveness of a feed. Welch (1968) assigned a value of 15 to 35% for K1 and 20-90% for K2. If the $K_1$and $K_2$ are more over less agrees to each other, the assimilation efficiencies considered to be high (Welch, 1968; Sambasivam *et al.*, 1982). In this study, the gross and net growth efficiency values were close to each other indicating a high assimilation efficiency for the feeds.

Only sparce information on the dietary mineral nutrition of prawns exist. In the present study, the important nutritive trace metals such as copper, zinc and manganese were studied with a view to formulate a suitable nutritionally balanced diet including the minerals.

Copper was found to be required in the diet of fin fishes.

Diets having 3 mg copper/kg showed higher weight gain in common carp. Deshimaru and Yone (1978) have remarked that copper may not be required in the diet of prawn .However, some of the natural feeds used for rearing prawns contain appreciable amount of copper, for eg., copper content in the Roteiferus plicate (brachionous) varies from 4 to 23mg/g on dry basis. Therefore, it may be considered that diet is a source of copper for prawns. In this study addition of copper to the diet did not improve the growth rate of prawns. Literature on the effect of dietary copper content on the growth and food conversion ratio of the prawns are not available.

Requirement of zinc in the diet of prawn has not been studied in any of the earlier works though its regulation in the body has already been confirmed (Byran, 1964, 1968). Deshimaru and Yone(1978) indicated that 0.2% of trace elements were required in the diet of the prawn *Penaeus japoincus*. The trace element mixtures used in their study contained zinc sulphate equivalent to about 34.5 mg of zinc per 100g diet. Compared to this, the zinc requirement shown in this study is lower.

Feeding the diet with manganese level varying from 0.21 to 2.60mg/100g diet to *P* indicus did not improve the growth and food conversion ratio (Ahamed Ali, 1988a). Kanazawa *et al.*( 1984) reported that the growth of *P japonicus* is dependent on the manganese concentration in the diets.The modification of the manganese. concentration in the diet had no beneficial effect on growth.

The selection of three feeds, PD1, PD2 and PD3, for the field experiments were done taking into consideration , the overall FCR and the percentage of survival, in the laboratory mass culture with due consideration to the various growth parameters obtained in the low density individual culture experiments. The comparable productivity ratio (73.99 to 95.29) with respect to the standard indicate that these feeds can very well be suggested as a replacement for the aquaculture.

The economics of the various feed mixtures shows that the per kg cost of the feed for imported one is Rs 12.55 whereas, the feed formulated in this study works out to 3.55 only. Taking the conversion factor into consideration, the cost of producing 1kg of prawns comes out to be in the range of Rs 10.05 to 14.91 for the PD feeds and under the same condition, the cost of the standard feeds was in the range of Rs 40.63 to 43.72 and the available local feeds are in the range Rs. 17.0 - 20.0. This represents a high economic advantage at the same time of doubles the production at the cost of a single production with any of the feeds available in the market, even if the market economy of the manufacture of the formulated feeds may double the cost of feed when it will be marketed for regular usage.

# Chapter V

# ENERGETICS

## INTRODUCTION

Bioenergetic is the study of the balance between energy supply in the food and energy expenditure, and require an examination of the physiological processes by which energy is transformed in living organisms. Energy expended as heat by animals is measured by calorimeter which is a general technique for measuring heat flux between two bodies.

The catabolism of food is organized within the animal to conserve free energy for use in anabolic and other life sustaining processes. The component of food which make a significant contribution to the energy supply of the animal could be characterized as three proximate principles, protein, fats and carbohydrates. The stiochiomerty of the oxidation of these classes of compounds allow calculation of the energy released as heat from measurements of respiratory exchange: oxygen consumption and carbon dioxide production, along with measurements of urinary nitrogen excretion. There have been reports of studies of energy utilization and expenditure for several species of fish by Cho *et al.* (1976) & Brett (1979).

Many of these investigations have been primarily concerned with the requirement of energy for swimming activity of the fish and have largely ignored the level of feeding and the type of the diet.

Nutritionists deal with defined chemical entities which play a role in the animal either as tissue components or their precursors, or as fuel which upon catabolism lead to the formation of useful intermediates to permit the completion of energy requiring process. The completion of the energy requiring process results in either an increase in the energy content of the animal (weight gain) or to the release of heat. Thus the utilization of dietary fuels does not cause any change in the energy content of the whole systems. All the inorganic compounds in the food release heat upon combustion, but for salmoinds fish the fats and proteins are the dietary components which are the main fuels. All these components play some part in the structure of the animals but the need for the energy can preclude their incorporation into tissue and lead to their catabolism. Thus the utilization of the components of each diet depends on both upon the level of intake and upon the make-up of the diet. In effect, both quantity and quality of the diet influence the metabolic partition of the components between storage and catabolism. It is this flexibility on the part of the animals to use all three components of the diet as fuels which leads to the complexities of the interactions among proteins, fats and carbohydrates. As a consequence, the energy value of the diet to the animal must be defined before drawing any conclusions as to the effect of the diet upon the growth of the animals. In fact, if the diet provides less energy to the animal than is needed to sustain the life process and to support its physical activities, tissue components will be capitalized in addition to the food. This overriding importance of the food as fuel means that the major factor regulating the amount of food consumed is its energy value in relation to the animals energy needs. As a consequence, the concentration of the nutrients which must be provided in the diet to adequately meet the requirements of animal depends upon the fuel value of the diet to the animal.

Dealing with the physiology of an organism in terms of energy budget accounts for the systems nature of energy processes in the animal. It take the view that energy is transferred and shifted between certain compartments. These compartments are food uptake, faecal losses, growth and respiration. The energy flow in organism will provide basic information on energy flow through the ecosystems (Jorgensen, 1983). For mussel larvae efficiencies of energetic process have been estimated by Jorgensen (1952; 1981), Bayne (1976) and Jespersen and Olsen (1982).

Fish characteristically require much higher protein level in the diet than are necessary for birds and mammals (Cowey and Sargent, 1979). This is probably because poikilotherms, unlike homeotherms, do not require a substantial non-protein energy source in the diet for the generation of heat. Even so there is evidence that if the protein content of fish diets is too high the excess is catabolised to provide energy for growth and as a result, protein conversion efficiency is depressed (Lee and Putnam, 1973).

Protein utilization depends essentially on species and size of the fish, environmental factors, protein quality, level of dietary protein and of utilizable dietary sources of energy and quantity of feed. The energy sources too is of great importance. Experiments with juveniles of rainbow trout fed with a practical diet resulted in an improved protein utilization with a reduction in the protein level of the diet and a lower growth rate (Cho *et al.*, 1976). Since high protein levels in the diet lead to considerable consumption of dietary protein for energy requirements, the energy level of the diet is of great significance. Growth rate and protein utilization by rainbow trout fed with a diet of reduced protein content may be improved if the dietary fat level is increased (Steffens and Albrecht, 1973, 1975)

A protein sparing effect depends strongly on the dietary energy sources. Lipids are suited for energy source in the trout diets. Native carbohydrates are less suited for fishes because of their poor digestibility, but may be used with success in carp diet to meet the energy requirements (Ogino *et al.*, 1976). In juveniles of carp, lipids and carbohydrates were equally effective in satisfying energetic needs (Takevchi *et al.*, 1979a). Using casien as an exclusive dietary protein source, the optimal ratio of digestible energy (KJ) to protein (%) was 13000 to 15000 KJ/Kg with a protein content of 31 to 32%. This is equivalent to a quotient between 400 and 480 (Takevchi *et al.*, 1979b).

The influence of energy level on the feed intake growth, food conversion and body composition of *Sparus aurata* was studied by Marais and Kissil (1979). In their study the feed intake and growth were significantly higher for fish on the lower energy (soyabean oil) diets. Energy conversion factor was also significantly lower in the lower energy diets. Increase in body protein, fat and energy were significantly higher in the lower energy treatment, however body composition was not affected by this treatment. It is well known that carnivorous fish normally require a higher percentage dietary protein than domestic monogastric animals and that protein is normally the most expensive part of the ration. Gerking (1955) suggested that a large part of the calorific requirements of fish is derived from protein, whereas homeotherms can use larger proportions of carbohydrates and fats for this purpose. The energy content of a diet may be changed by varying either the percentage carbohydrate or fat ration.

Protein and energy relationships are considered to be the basic data in defining other nutritional requirements, and knowledge of the optimal level of protein and protein sparing effects of non-protein nutrients such as carbohydrates and lipid is effective in reducing feed costs. Relevant data concerning energy to protein relationship in prawn nutrition are severely limited. Sedgwick (1979) reviewed the influence of dietary protein and energy on growth, food consumption and food conversion efficiency in *Penaeus merguiensis* Deman. AQUACOP (1976) estimated that a total dietary energy content of 3.3 Kcal/g was required for optimal growth of *Penaeus monodon* fed on a diet containing 40% protein. Examination of the result of Colvin (1976) shows that substitution of protein by potato starch, involving only a small change in calorific value (4.8-4.7 kcal/g) did not significantly affect growth in *Penaeus indicus* in spite of reduction of protein from 53.1 to 42.8%. Protein sparing may therefore be effective in reducing the feeding costs of intensive culture of prawns by minimizing the requirements for maximum growth. Bautista (1986) studied the response of *Penaeus monodon* juveniles to varying protein/energy ratio in the test diets. The minimum protein requirements of shrimp were also reported to be dependent upon the presence of their dietary components from which carbon chains can be catabolized for basal energy requirements (Andrews *et al.*, 1972). The ratio of protein to total energy of the diet has also been shown to affect the protein requirements in prawns (Bages and Sloane, 1981; Hajra *etal.*, 1986; Gomez *et al.*, 1988). Excess energy in the food may limit consumption, for prawn, like other animals feed to satiate energy requirements. On the other hand, sub-optimum level of non-protein energy may necessitate additional amount of protein to satisfy the energy needs.

Many investigations state that they have used isoenergetic diets to determine the protein requirements. However, since the metabolizable energy of the various ingredients has not yet been determined for most crustaceans, these workers have used various estimated physiological fuel values in expressing the protein requirement in relation to the dietary energy level. The use of some energy value for the dietary nutrients of different sources for different species of crustaceans may lead to inconsistent result because these values are mostly species and protein sources specific. In many cases the energy sources are reported to have a sparing action on protein (Hysmith *et al.*, 1972; Capuzzo and Lancaster, 1979; Fair *et al.*, 1980; Bhasker and Ahamed Ali, 1984; Gomez *et al.*, 1988). High efficiency of digestion of protein from various sources has been reported in shrimp and prawns (Nose, 1964; Lee, 1970; Forster and Gabbott, 1971; Condrey *et al.*, 1972; Fenucii *et al.*, 1982; Ashmore, 1985; Ahamed Ali, 1988a; Akiyama, 1988; Akiyama *et al.*, 1988).

Several studies have been made on the effect of total energy intake and of dietary calorie sources on feed conversion, protein conversion and weight gain by different species of fish. Lee and Putnam (1973) reported that as the fish eat to meet their energy requirement, only those diets which were low in both total energy content and total crude protein resulted in reduced weight gain.

A series of investigations were carried out in recent years on the energy conversion, energy metabolism and food conversion in some of the penaeid prawns of India (Qasim and Easterson, 1974; Laxminarayana and Kutty, 1980; Sumitra and Ramdas, 1982; Thomas *et al.*, 1984).

The presentinvestigation discusses the energetics of the prawns related to the formulated diet.

## RESULTS

The value of metabolizable energy, protein content and the P/E ratio of the formulated feeds are given in Table 5.1. The PD2 gave the highest value for metabolizable energy followed by PD1, PD4, PD5 and PD3. The standard feed recorded the lowest energy value. The P/E ratio ($mgKJ^{-1}$) ranged from 22.42 for PD1 to 32.7 for PD5. The feeds PD1, PD2, PD3 and the standard are having the ratio at a close range, between 22.4 and 24.5. The relation between P/E ratio with the growth rate is given in Fig.

Table 5.1 P/E ratios of feeds

| Feeds | Protein (mg) | Metabolisible energy(KJg-1) | P/E ratio (mg KJ-1) |
|---|---|---|---|
| STD | 278 | 11.79 | 23.57930 |
| PD1 | 301 | 13.42 | 22.42921 |
| PD2 | 337 | 13.93 | 24.19239 |
| PD3 | 314 | 12.28 | 25.57003 |
| PD4 | 409 | 12.97 | 31.53430 |
| PD5 | 422 | 12.87 | 32.701 |

5.1 for the three species of prawns studied. A gradual increase in growth rate was observed with the increase in P/E ratio for the *M. dobsoni* in all the three phase of growth. For *P.monodon* in the first two phases growth rate increased with P/E ratio and in the third phase a decrease in growth rate was observed with P/E ratio. The growth rate was found to be decreasing in the first phase of growth with increase in the P/E ratio in the case of *P. indicus* while growth was found to be unaffected with increase in P/E ratio in third phase.

A significant relation was observed between the metabolizable energy content of the feed and the percentage of survival. The feed PD2 which has the highest metabolizable energy recorded the highest percentage of survival with all the three species of prawns and at all the growth phases; 97.2%. 92.5% and 90.1% for *P. indicus,* 95.4%, 93.2% and 90.1% for *P.monodon* and 93.2%, 90.5% and 83.5% for *M. dobsoni* for the first, second and third phases respectively. The lowest percentage survival was found to be associated with the standard feed, which was the feed with the lowest energy (11.79 KJ/g).

The result of the investigation on apparent digestibility in terms of protein consumption are given in Table 5.2. The values indicate a considerably high digestibility of the feeds for all the three species with the formulated and standard feeds. The values were always above 95% and no considerable variation between the feeds and also between the prawns were observed. In the case of *P. indicus* the apparent digestibility ranged between 96.68 with the standard feed to 94.44 with PD2. The apparent digestibility for the *M. dobsoni* ranged from 96.49 with standard to 99.40 with PD2. *P. monodon* showed a digestibility which ranges from 98.20 with PD3 to 99.5 with PD2.

The energy conversion efficiencies are given in Table 5.3.The energy consumption varied with the species and also with the feeds. In the case of *P.indicus* the maximum consumption was

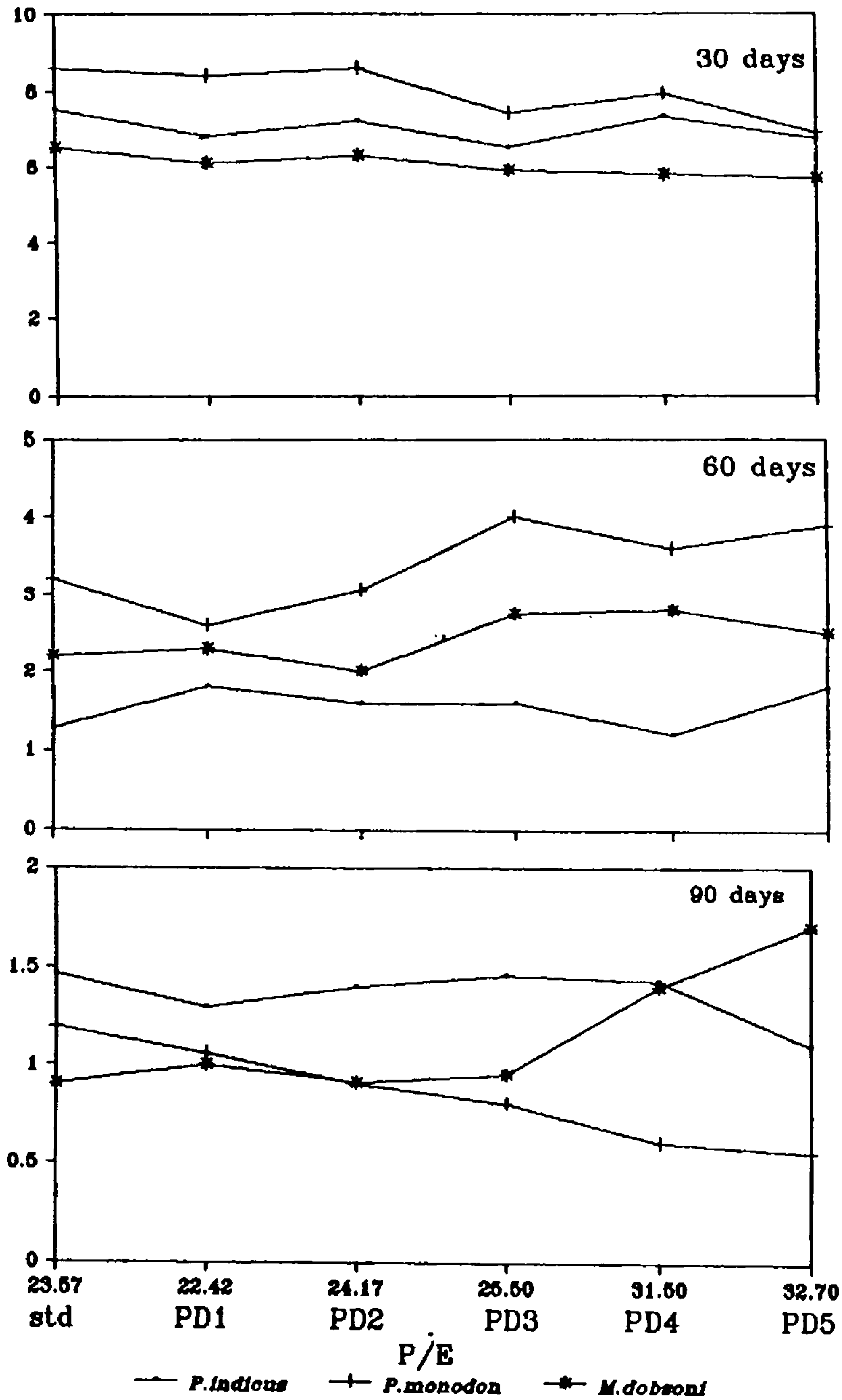


**Fig. 5.1 Growth rate of prawns fed with diets of varying Protein/Energy ratios**

Table 5.2 Apparent Digestibility

a) P.indicus

| Feeds | Feed consumed (g) | Protein consumed (g) | Qty of feacel matter (g) | Qty of protein in feacel matter (g) | Apparent digestibility (%) |
|---|---|---|---|---|---|
| STD | 25.00 | 6.95 | 2.50 | 0.23 | 96.69064 |
| PD1 | 25.00 | 7.52 | 1.90 | 0.08 | 98.93617 |
| PD2 | 20.00 | 6.74 | 1.50 | 0.03 | 99.55489 |
| PD3 | 20.00 | 6.28 | 1.80 | 0.07 | 98.88535 |
| PD4 | 20.00 | 8.18 | 2.90 | 0.17 | 97.92176 |
| PD5 | 18.00 | 7.59 | 2.60 | 0.13 | 98.28722 |

b) P. monodon

| | | | | | |
|---|---|---|---|---|---|
| STD | 42.00 | 11.67 | 2.40 | 0.19 | 98.37189 |
| PD1 | 30.00 | 9.02 | 1.60 | 0.08 | 99.11308 |
| PD2 | 22.00 | 7.41 | 1.30 | 0.03 | 99.59514 |
| PD3 | 22.00 | 6.9 | 1.30 | 0.05 | 99.27536 |
| PD4 | 25.00 | 10.22 | 1.20 | 0.09 | 99.11937 |
| PD5 | 25.00 | 9.79 | 1.20 | 0.09 | 99.08069 |

c) M. dobsoni

| | | | | | |
|---|---|---|---|---|---|
| STD | 40.00 | 11.12 | 3.80 | 0.38 | 96.58273 |
| PD1 | 26.00 | 7.82 | 1.90 | 0.09 | 98.84910 |
| PD2 | 22.00 | 7.41 | 1.60 | 0.04 | 99.46018 |
| PD3 | 25.00 | 7.85 | 1.70 | 0.06 | 99.23566 |
| PD4 | 28.00 | 11.45 | 2.10 | 0.15 | 98.68995 |
| PD5 | 28.00 | 11.81 | 2.40 | 0.18 | 98.47586 |

Table 5.3
Protein efficiency ratio of three species of prawns

| Feeds | P/C ratio | PER | | |
|---|---|---|---|---|
| | | a) *P. indicus* | b) *P. monodon* | c) *M. dobsoni* |
| STD | 1.06 | 0.928 | 0.728 | 0.63 |
| PD1 | 0.755 | 0.744 | 0.77 | 0.84 |
| PD2 | 0.926 | 0.87 | 1 | 0.916 |
| PD3 | 0.941 | 0.89 | 0.98 | 0.8662 |
| PD4 | 1.36 | 0.66 | 0.622 | 0.602 |
| PD5 | 1.58 | 0.7 | 0.68 | 0.56 |

observed with feed PD1 and the lowest consumption was given with PD3, but the contribution of the feacal matter towards the energy utilization was found to be maximum with PD4 and minimum with PD3. Thus the energy assimilation (conversion) was found to be maximum with PD1 (92%) and the minimum was PD4 (73%). The maximum increase in the calorific value of the prawn was observed with feed PD1 and the feed PD5 recorded the lowest increase.

In *P.monodon* the order of energy consumption was STD > PD1> PD4 > PD5 > PD2 > PD3, but contribution of the faecal matter towards energy utilization was STD > PD1 > PD2 > PD3 > Pd5 > PD4. Thus energy assimilation was maximum for PD4 ( 90.25%) and minimum for STD (70.40%). The energy retention was in the order PD2 > PD3 > STD > PD1 > PD5. The energy utilization ratio (other than feacal) was in the order PD5 > PD4 > PD1 > PD2 > PD3 > STd.

In *M. dobsoni* the energy consumption was observed to be the highest with STD (112.8%) and the lowest with PD3 (73.25%) but the contribution of the faecal matter towards the energy utilization was maximum for STD (41.22%) and the minimum for PD5 (11.25%). Thus energy assimilation was highest with PD5 (86.95%) while the lowest was given by PD3 (74.84%).The increase in claorific value was maximum with STD and minimum with PD5. The energy retention ratio highest in PD3 (36.91) and minimum in PD5 (24.58). The energy utilization (other than feacal) was highest in PD5 (62.37) and lowest in STD (33.55).

The result of P/C ratio (Protein to Carbohydrate ratio) and protein efficiency ratio (PER) of three species of prawns are given in Fig 5.3. The formulated feeds PD1, PD2, PD3 give the highest PER in three species of prawns. P/C ratio is less than 1 for PD1, PD2 and PD3 whereas for STD and PD4, PD5 the ratio is greater than 1.The biomass production also was in the same order.

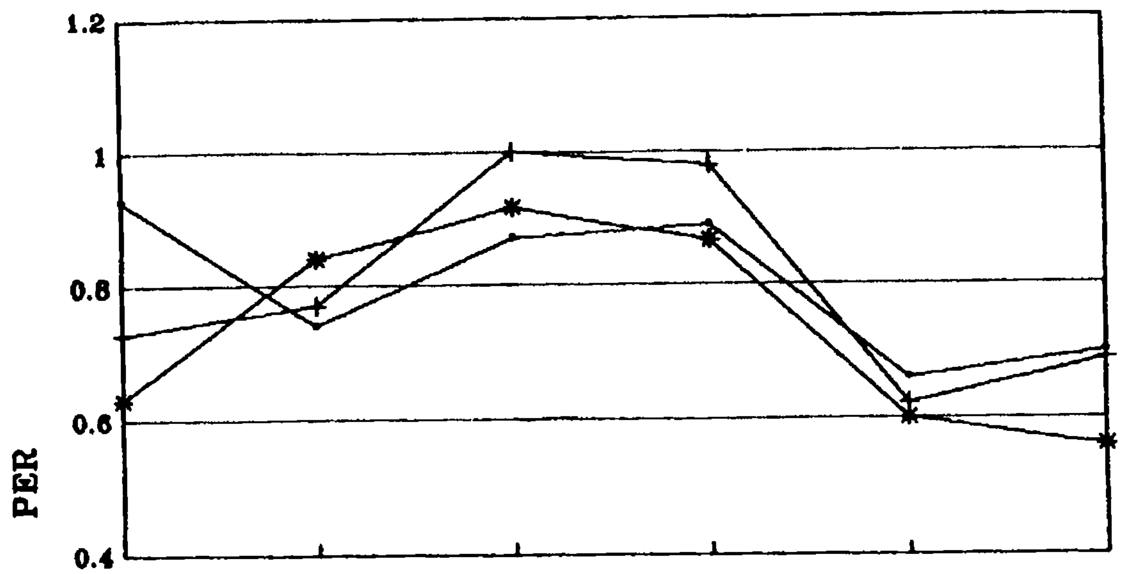


**Fig. 5.2 Protein efficency ratio of prawn fed with diet varying P/C ratio**

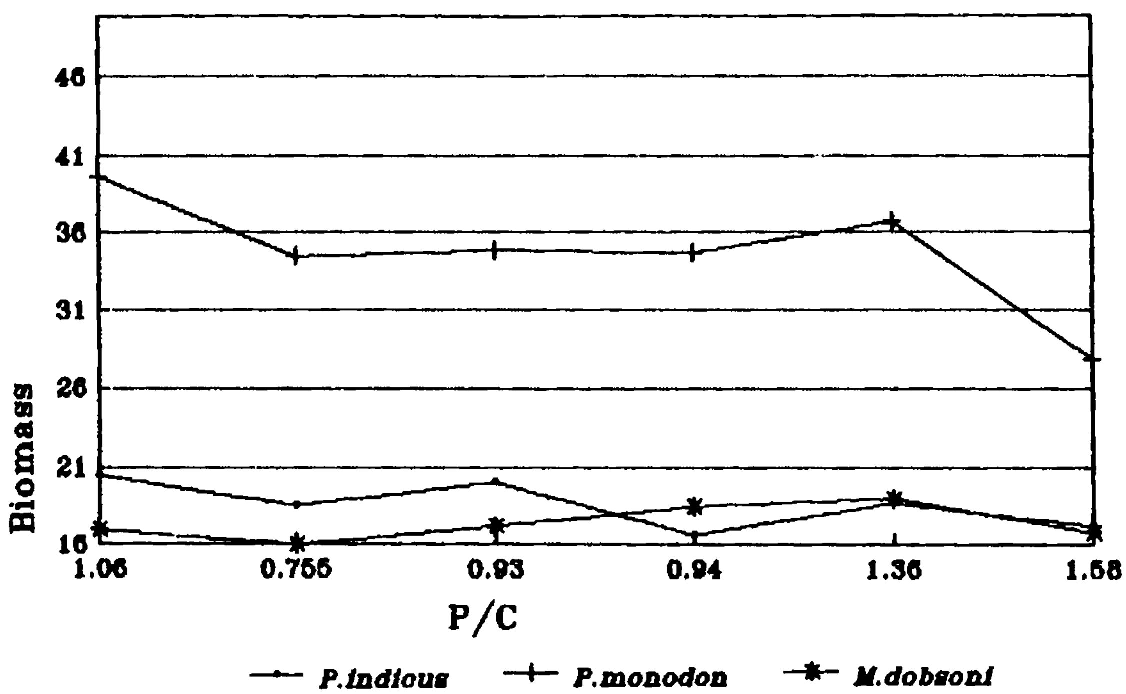


**Fig. 5.3 Biomass of prawn fed with diet of varying P/C**

# DISCUSSION

The energy budget of the prawns proposed by Klandatos and Apostlopoulos (1986) gave the relationship between utilization and loss as

$$Q_c - Q_w = Q_g + Q_s + Q_d + Q_a$$ where the energy values,

$Q_c$ for consumed food
$Q_w$ for faeces and nitrogenous excretion
Qg for matter incorporated into the body
$Q_s$ for metabolism
$Q_d$ for specific dynamic actions and
$Q_a$ for activity.
$Q_s$, $Q_d$ and $Q_a$ are considered as the energy used in total metabolism and $Q_g$ is the part of the ingested energy $Q_c$ used for increasing the body weight. The remaining $Q_w$ is included in $Q_s$.

In this discussion the $Q_w$ is restricted to the contribution of the faecal matter only and the contribution from the urine is added along with the energy spared for metabolic activity $Q_s$ and the the equation is modified as

$$Q_c - Q_w = Q_s + Q_q.$$

The values of $Q_c$(energy consumed), $Q_w$ (energy given through faecal matter), $Q_g$ (energy retained with the body), and the $Q_s$ (energy utilized) for the three species of prawns are given in the Table 5.4 where the last two terms are expressed as the ratio to $Q_c$. Except for *P. indicus*, the energy conversion ratio was greater for greater P/E ratio value, a result which goes in tune with the equation of protein transferred to the body. But a high energy retention and low energy utilization was observed with the low P/E ratio and P/C ratio feeds, suggestive of a lower metabolic energy expenditure for normal growth with low P/E ratio and P/C ratio of feeds. In other words the optimum

Table 5.4
Energy balance sheet
a) P.indicus

| Feeds | Metabolisible energy (a)Kcal/g | Feed consumed b(g) | wt. increased c (g) | energy consumed d = aXb | Energy in feacal f | Energy Given g =ex | Energy conservation h =(d-g/d)x100 | Increase in energy E90*W90-E0*W0 | Energy retention ratio j = i/d | energy ut ratio d-g-i/d |
|---|---|---|---|---|---|---|---|---|---|---|
| STD | 2.82 | 25 | 6.64 | 70.5 | 1.01 | 16.73 | 76.27 | 30.04 | 42.61 | 33.66 |
| PD1 | 3.21 | 25 | 5.6 | 80.25 | 1.02 | 10.92 | 86.39 | 29.43 | 36.67 | 49.72 |
| PD2 | 3.33 | 20 | 5.91 | 66.6 | 0.98 | 10.46 | 84.29 | 24.08 | 36.16 | 48.14 |
| PD3 | 2.93 | 20 | 5.68 | 58.6 | 0.97 | 9.94 | 83.04 | 23.27 | 39.71 | 43.33 |
| PD4 | 3.1 | 20 | 5.48 | 62 | 1.01 | 16.11 | 74.01 | 22.3 | 35.97 | 38.05 |
| PD5 | 3.08 | 18 | 5.34 | 55.44 | 0.97 | 13.51 | 75.63 | 21.3 | 38.42 | 37.21 |

b) P. Monodon

| Feeds | Metabolisible energy (a)Kcal/g | Feed consumed b(g) | wt. increased c (g) | energy consumed d = aXb | Energy in feacal f | Energy Given g =ex | Energy conservation h =(d-g/d)x100 | Increase in energy E90*W90-E0*W0 | Energy retention ratio j = i/d | energy ut ratio d-g-i/d |
|---|---|---|---|---|---|---|---|---|---|---|
| STD | 2.82 | 42 | 8.55 | 118.44 | 1.71 | 35.06 | 70.40 | 40.4 | 34.11 | 36.29 |
| PD1 | 3.21 | 30 | 7.03 | 96.3 | 1.21 | 13.57 | 85.91 | 31.9 | 33.13 | 52.79 |
| PD2 | 3.33 | 22 | 7.21 | 73.26 | 1.01 | 9.45 | 87.11 | 27.95 | 38.15 | 48.96 |
| PD3 | 2.93 | 22 | 6.77 | 64.46 | 1.01 | 8.87 | 86.24 | 28.5 | 44.21 | 42.03 |
| PD4 | 3.1 | 25 | 6.4 | 77.5 | 9.8 | 7.55 | 90.26 | 28.2 | 36.39 | 53.87 |
| PD5 | 3.08 | 25 | 6.72 | 77 | 1.02 | 8.20 | 89.35 | 25.01 | 32.48 | 56.87 |

c)M.dobsoni

| Feeds | Metabolisible energy (a)Kcal/g | Feed consumed b(g) | wt. increased c (g) | energy consumed d = aXb | Energy in feacal f | Energy Given g =ex | Energy conservation h =(d-g/d)x100 | Increase in energy E90*W90-E0*W0 | Energy retention ratio j = i/d | energy ut ratio d-g-i/d |
|---|---|---|---|---|---|---|---|---|---|---|
| STD | 2.82 | 40 | 7.01 | 112.8 | 1.91 | 41.22 | 63.46 | 33.74 | 29.91 | 33.55 |
| PD1 | 3.21 | 26 | 6.6 | 83.46 | 1.61 | 20.92 | 74.93 | 26.15 | 31.33 | 43.60 |
| PD2 | 3.33 | 22 | 6.7 | 73.26 | 1.21 | 14.54 | 80.15 | 26.18 | 35.74 | 44.42 |
| PD3 | 2.93 | 25 | 6.8 | 73.25 | 1.41 | 18.43 | 74.84 | 27.04 | 36.91 | 37.93 |
| PD4 | 3.1 | 28 | 6.9 | 86.8 | 1.12 | 16.56 | 80.92 | 24.65 | 28.40 | 52.52 |
| PD5 | 3.08 | 28 | 6.62 | 86.24 | 1.02 | 11.25 | 86.95 | 21.2 | 24.58 | 62.37 |

ratios of P/E ratio and P/C ratio in the feeds PD1, PD2, and PD3 results in an optimum growth conditions.

In aquaculture practices, the yield per individual stocked or the biomass production has a great importance. In many cases, a linear relation was observed between the amount of food consumed and weight gain. The metabolic expenditures caused by feed intake, assimilation and biosynthesis of fish biomass also increase proportionally with the amount of feed consumed. The relative percentage of protein and other energy sources in the feed was found to have a profound influence on the consumption of feed and weight gain. Fish preferentially utilize protein energy for metabolism. Though an increase in the available energy form will lead to a reduction in food intake and to a consequent better food utilization through a protein sparing effect of the carbohydrate (Bergot, 1979 and Puffier 1980a, b), an ultimate reduction in food consumption, as the fish becomes fatter, followed by net decrease in maximum gain was reported (Hilton and Slinger, 1983).

In the present study, the growth rate of the prawns was found to increase with an increase in the P/E ratio from 22.42 to 32.7 mg $KJ^{-1}$. This is in close agreement with the observations of earlier workers. The notable feature of the present study is that though the growth rate was greater with high P/E ratio, the biomass production was found to be at lower at higher P/E value resulted from a lower food intake in agreement with the earlier suggestions. Energy utilization was high with high P/E value. These all clearly indicates the significant modification that has been brought about by the variation in the percentage of energy sources other than protein. The formulated feeds were divided into two groups based on the protein to carbohydrate ratio (P/C ratio). P/C ratio showed marked influence on PER, lower P/C ratio giving the highest PER. An increase in the PER with the addition of energy sources other than the protein was reported earlier with a condition that the biomass production will indicate a fall. This was suggested to be more pronounced with the increase in carbohydrate content (Machiels and van Dam, 1987). In this study the increase in PER was found to be retaining the biomass production without a fall at lower P/C value. The considerable increase in the protein content with decrease in the carbohydrate to keep the total energy of the feed at a comparable limit in the case of the higher P/C ratio groups can be attributed to this lower biomass production as the growth was always observed to be declining to an increase in the protein content above the optimal protein level. Thus the increase in the biomass production with the lower P/E ratio and P/C values was resulted from the optimum protein content of the feed along with the protein sparing action of the relatively high carbohydrate content.

The apparent digestibility of protein indicated a comparable digestibility with all the feeds in this study does not indicate any specific selectivity towards any variation in the protein sources between the feeds.This is clearly evident from the high PER observed with P/C ratio feed groups. The optimal protein utilization was closely related to the energetic value of the diet and that carbohydrate and lipid can increase growth efficiency at such optimal levels of protein in this study, was agreed with findings of Sedgwick (1979) in *P. merguiensis*. The high sparing action of carbohydrate over lipid as evidenced by the higher PER when a higher amount of carbohydrate was fed (Tapioca flour) was in agreement with the findings of Ringrose (1971) who found isocaloric substitution of protein by wheat middlings in brook trout. The lower PER obtained with standard and other two formulated diets PD4 and PD5 suggest that more protein is diverted into energy if the caloric requirements in the diet are not satisfied. Cowey and Sargnet (1972) observed the same condition, if the diet does not contain sufficient energy, protein is used for energy rather than for growth. This is economically wasteful and therefore it is essential that caloric sources supply energy and spare the protein for growth.

The higher amount of energy needed by the prawns at higher levels of protein to attain approximately the same growth rate obtained at lower protein levels implies that when non-protein energy sources are limiting, protein is catabolized. The effective protein levels of 30-42% found in these experiments are consistent with results obtained by Lee (1971), AQUACOP (1977) and Alava and Lim (1983).

The high feed conversion ratio obtained with prawns fed with the lowest caloric diet (STD) implies that prawns ate more food to overcome energy inadequacies. This would suggest that the amount of calories taken in by the prawns somehow affected the amount of food consumed. Control of food consumption through dietary energy density, in fact, has been reported in other species of fish (Palaheime and Dickie, 1966; Page and Andrews, 1973). It would appear therefore, that penaeid prawns do not depart substantially from other species of fish in this aspect of nutrition. The comparatively higher survival rates obtained with formulated feed due to the right proportion of protein and non-protein calorie in the diets and also optimal levels of protein and higher energy level in the formulated diet could have provided enough resistance against molting stress which was agreed with findings of Alava and Lim (1983).

# Chapter VI

# SUMMARY

Aquaculture have been identified as a major frontier in fish production in India for domestic consumption export and employment generation. The population of India is expected to rise to 100 crores by 2000 AD and if 70 percent of this is considered as non-vegetarians (mainly those who consume fishes), India has to harvest 13 million tonnes of fishes. The major resources of India are rivers, reservoirs, inland and coastal saline and alkaline soils constituting about 9.4 million ha. The total production potential of these resources has been estimated as 27.5 million tones. The attainment of this potential requires a considerable effort. Through the application of improved technologies in hatchery,water management and feeding instead of the traditional farming, even an exploitation at the rate of 50% represents a quantum jump in production and rural incomes.

Promotion and practice of aquaculture in India mainly constrained from the non availability of inexpensive food which have a high conversion value and which is easily digestible, readily acceptable and not easily disintegrated. The conventional food stuffs and the artificial feeds used for feeding the prawn in most of the western countries ( clam meat, and fish squid meals) are financially far beyond the reach of the average Indian fish farmer. Since the feeds comprise one of the largest items in the recurring expenditure of a prawn farm it is highly desirable to develop cheaper prawn diets so as to make prawn culture a profitable venture.

Keeping the criteria of a quality prawn diet , the present study is undertaken to develop a low cost nutritious diet by utilizing locally available natural materials, animal wastes and factory byproducts, including protein sources as major ingredients. Different combinations of the ingredients were used in and the suitability of these feeds for prawn farming was assessed. To know the nutritive value, the ingredients and diets, were analyzed biochemically including quantitative estimation of proteins, carbohydrates and lipids. The physical evaluation of diets were also carried out and found to have a high water stability and storage stability. The results of experiments done for physical evaluation suggest that present composition of the diet can be used effectively in pellet forms of varying size depending upon the need of the experimental animals. It was further ascertained that the diet can be used with both penaeid and non- penaeid prawns, since it withstands 7 hours in seawater without major disintegration. This investigation confirms the good binding capacity of the low cost binder, tapioca flour.

The low density laboratory culture experiments with different size groups of the three common species of prawn presented highly encouraging results. Compared to an imported standard feed, the formulated feeds showed better growth rate, percentage of survival, feed conversion ratio and, acceptability. The results were more significant as the standard feed contained growth promoting hormones. The better growth can be attributed to the optimum protein level in the feeds and better palatability and digestibility of the feeds. The combinations of protein of animals and plant origin that were used also may have contributed to the higher efficiency. The performance of the feeds in the high density laboratory culture was also significantly better than the standard in view of the non inclusion of growth promoting hormones in the formulated feeds.

The field studies indicated a feed efficiency which matches with the standard in terms of growth performance. The net biomass production was above 70% compared to the standard. The cost efficiency of the feeds was observed to be considerably high compared to standard.

The protein efficiency, digestibility and the energy efficiency all suggest a significant upper hand for the formulated feeds than the standard. A significant relation was observed between the protein to carbohydrate ratio and the protein efficiency values to the growth parameters. A lower P/C ratio promotes a better growth.

This study offers a special significance in the light of a need for an economically viable aquaculture practice to promote the prawn production. The feed contained ingredients that are easily and continuously available and which are either waste products or low cost materials. The use of tapioca instead of costly alginate and agar as a binder also indicated very promising. The nonusage of growth promoting hormones can be compensated by addition of plant protein.

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