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Different Types of Formulated Feeds on the Biochemical Composition of Cultured Shrimp, *Penaeus monodon* (Fabricius, 1798)

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Abstract: Four different types of feeds were formulated using wet reduction, dry reduction, industrial and traditional fish meals. Among the four types of feeds wet reduction feed showed highest percentage of protein, lipid, gross energy and it was lowest in traditional feed. The traditional feed showed maximum of 3.6 % of ash and the dry reduction feed had minimum of 0.3% ash. The shrimp *P.monodon* fed with wet reduction feed showed significantly higher weight gain of 33.5 g where as it was lower of 21.5 g in shrimps fed with traditional feed. The shrimps consumed 296 g of wet reduction feed with less FCR (1.3) where as shrimp fed with traditional feed consumed 368g of feed with high FCR (2.0). Survival rate was found to be similar for all the shrimps fed with different feeds reveals that the quality of the feeds influences only the growth rate but not the survival rate. The proximate composition after 140 days culture of shrimps, wet reduction feed fed shrimp showed high nutritive composition than compared to other feeds fed shrimps. The amino and fatty acid profile also showed the similar results. The study concluded that quality of feed ingredients and feed formulation had an influence on the whole body composition of the cultured shrimp.

Key words: Fish Meal · Quality · *P. monodon* · Biochemical Composition

INTRODUCTION

Crustacean meat gained global reception and they are extensively fished and marketed in all the maritime states of India and abroad. Apart from the delicacy, shrimp meat is a major source of nutritious food for human being and also has got high biological value compared to protein from many other sources due to easy digestibility [1]. The worthiness of the seafood to the human beings is to maintain a state of positive health and optimal performance by providing all essential nutrients in adequate quantities to prevent deficiency diseases and also to prevent diet related chronic disorders. The deficiency may be minimized to some extent by making available cheaper nutrient rich ingredients which are available to local communities to produce nutritionally enriched crustaceans [2].

Nutritive values of crustaceans depend upon their biochemical composition, such as protein, amino acids, lipid, fatty acids, carbohydrate, fiber and ash [3]. The proximate compositions of shrimp muscles are dependent on factors such as species, growth stage, feed and season. Studies on the biochemical composition of edible organisms are important from the nutritional point of view. So in the present study was carried out to prepare different types of feeds were formulated to understand the effect of formulated feeds fed shrimp *Penaeus monodon's* organic constituents.

MATERIALS AND METHODS

Preparation of Fish Meals: Shrimp feeds were formulated using 4 different types of fish meals namely wet reduction, dry reduction, industrial and traditional fish meals. Wet reduction fishmeal was prepared by following the method of Kamasastri and Ramananda [4]. From the 42 dominant trash fish species, 125 g of each species was taken in fresh condition to attain 5 kg of whole fish composition to get 1 kg of fish meal. The aggregated 5 kg trash fishes were steamed for 15 minutes to soften the flesh, bones to coagulate the protein and fat depots and to liberate oil and water. Then it was pressed to remove a

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large fraction of oil and water from the solid part of the fishes. The oil and water is known as stick water and rest of the solid part was known as press cake. Stick water was concentrated in a water bath (70°C) to evaporate the water and the remaining oil was added with the press cake and it was dried for 5 to 6 hours at 60°C in a hot air oven and it was powdered. The meal prepared by this method was denoted as wet reduction fish meal. Dry reduction fishmeal was prepared by following the method of Mathew [5]. 125 g of each species of the 42 dominant trash fish species was taken in fresh condition to attain 5 kg of whole fish having the moisture content of about 72 to 80%. Fishes were sun dried hygienically using fish drying racks for 3 to 4 days to bring down the moisture content below 10%. The dried fishes were pulverized and sieved using 200 micron sieve to get uniform particle size of dry reduction fish meal. Traditional fishmeal was prepared from unhygienically dried trash fishes in the fishing villages for making poultry feeds. Industrial fish meal was developed from a single edible fish procured from a fishmeal export company of Tuticorin. The collected fish meals were stored hygienically for the comparative analysis.

Proximate Composition of the Ingredients: The proximate composition such as moisture, protein, lipid, ash, carbohydrate, gross energy of all prepared fish meals and locally purchased terrestrial ingredients like ground nut oil cake, rice bran, tapioca flour and soya bean meal, broken rice were analyzed according to standard procedure of AOAC [6].

Feed Preparation: Shrimp feed was prepared from required amount of feed ingredients, were finely ground with similar particle size and were selected based on the composition shown in Table 1 all ingredients were thoroughly mixed. About 450 ml of water was added to 1 kg of dry mixture and mixed well to form dough. Then the dough was steam cooked at 60-70°C for 10 minutes to gelatinize the starch. After steaming, it was pressed through a hand pelletizer using 1.0 mm, 1.8 - 2.0 mm, 2.3 to 2.5 mm diameter dies and pellets were collected as long strands in trays. The strands were cut into pellets of 3 to 4 mm length. The trays with moist pellets were dried in a hot air oven at 45°C for 8 hours to reduce the moisture below 10%. After drying, uniform pellets were stored in airtight containers at room temperature as stock feed.

Proximate Composition of the Feeds: The proximate composition of the prepared experimental feeds were determined by using standard methods; Viz., protein [7], Carbohydrate [8], Lipid [9], Ash, moisture[6] and gross energy [10].

Feeding: For the feeding trial, PL-20 of *P. monodon* were brought to the laboratory by using bucket and acclimatized to the laboratory condition in the range of salinity 25 - 30 ppt; temperature 25 - 30°C; pH 7.5 - 8.5 and dissolved oxygen 5 - 6 ppm. After acclimatization, the shrimps were stocked at a density of 10 number of PL 20's of *P. monodon* were transferred in to grow out tanks with 500 L capacity of filtered sea water at the level of 100 L at the stocking density of 1 individual for 10 liters. During the experimental period the shrimps were fed with four different types of formulated feed at 10% of their body weight. Feeding was done by multiple feeding depending upon the feed consumption by the shrimp, the total amount of daily feed were divided into 4 and fed at 4 hours intervals. The water was exchanged daily in the morning hours and left over feed and faecal matter was removed while water exchange. Triplicate was maintained for each feed. Sampling was done every two days to assess the health condition and weight gain of the experimental shrimps. The shrimps were harvested after the 140 days experimental period.

Environmental Parameters: The environmental parameters were monitored at every morning around 6 AM during the entire experimental period. The salinity, dissolved oxygen, pH and temperature were measured by using hand refrectometer, DO meter, pH pen and thermometer.

Biochemical Composition of Culture Shrimp: After termination of 140 days feeding trails with five different feeds the experimental shrimps were removed from the water and transported to the laboratory in live condition and washed with distilled water to remove dust and algal particles and eventually ice killed and dried at 60°C for 24 hours in an oven and the dried samples were finely grounded and used for the estimation of the proximate composition.The Protein [7], carbohydrate [8], lipid [9], ash and moisture [6] of the experimental shrimps were analyzed and the values were expressed as % dry weight basis. Each analysis was determined with three replicates.

The amino acids were estimated in HPLC system with a fluorescent detector (FLD - 6A) with amino acid standard as described by the method of Baker and Han [11]. For fatty acid analysis, samples were homogenized with chloroform:methanol (2:1 v/v) mixture and the fat were extracted and it was esterifies with 1% H_2SO_4 and fatty acid methyl ester. The fatty acid methyl esters of the samples were injected into the gas chromatography (GC -6890) [12]. The fatty acid peaks were detected by flame ionization detection and individual methyl esters were identified by comparison to known standards.

RESULTS

Four different feeds were formulated using four types of fish meals. The shrimps fed with the feeds growth rate and their compositions are presented in Table 1. Except the quality variation of fishmeal, all other ingredients were same for all the four feeds. Composition of the ingredients also varies according to the nutrient requirements of the culture shrimps.

The proximate compositions of the selected low cost feed ingredients are presented in Table 2. Except traditional fishmeal (16.54%) all other ingredients had allowable limit of <10% moisture. Protein and lipid content were high in fish meals and low in terrestrial ingredients. Ash and gross energy content were high in fish meal ingredient whereas carbohydrate was high in terrestrial ingredients.

The proximate compositions of the formulated feeds are shown in Table 3. Significant difference was observed in all the parameters between the feeds because all the nutrient parameters were high in wet reduction feed and was low in the following feeds. Significant variation in the content of the nutrients was observed only in traditional feeds. Other than the proximate composition, total available energy was also observed in the experimental feeds especially high in wet reduction feeds.

The overall 140 days culture results of the effect of different quality of feeds on the growth rates of shrimps are presented in Table 4. Shrimps fed with wet reduction feed in tank A, readily accepted and consumed well compared to other shrimps fed with other type of feeds. After termination of 140 days culture period, average body weight (g) was high in wet reduction feed fed shrimps (37g) compared to dry reduction fed shrimps (27.4g), industrial feed (30g) and it was very less for traditional feed fed shrimps (20g). Also the shrimps showed better weight gain of 33.5 g and specific daily weight gain of 0.26g were compared to other feeds used for feeding culture shrimps. Total feed intake (385g) and weight gain (296g) also high with less FCR (1.3) was observed in the wet reduction feed fed shrimps, but 368g feed was taken by the traditional feed fed shrimps with lesser weight gain of 184g with high FCR (2.0).

Water quality parameters in all the tanks showed similar trends and the values are shown in Table 5. The salinity did not show much variation (25 - 28 ppt) and the dissolved oxygen maintained during the entire experimental period for all the feeds fed tanks were 5.5 - 6.0 ppm. The pH for the present study was maintained at 7.8 - 8.4 for all the tanks and the water temperature of the tanks was found to be 27 - 31°C.

The whole body proximate composition of shrimp *Penaeus monodon* fed with different types of feed expressed in percentage (dry weight basis) is illustrated in Table 6. Moisture content was lesser (72.44%) in shrimps fed with wet reduction feed whereas it was higher (80.24%) in shrimps fed with traditional feed. The protein content is significantly different among shrimps receiving various dietary treatments and it ranged between 14.82 and 24.58%. Lipid content of shrimp fed with wet and dry reduction feeds was significantly different from shrimps fed with industrial and traditional feeds. The carbohydrate content differed significantly among shrimps receiving various diets and it ranged between 1.03 and 3.0%.

Lesser percentage of protein, lipid, carbohydrate, fiber and ash content were (14.82, 2.24, 1.03, 2.59 and 1.81 respectively) was observed in shrimps fed with traditional feed. Higher percentage of protein (24.58), lipid (8.32), carbohydrate (3.0), fiber (3.65) and ash content (3.04) were noticed in shrimps fed with wet reduction feed. Fiber content was higher (3.67%) in shrimps fed with industrial feed.

Essential and non-essential amino acid profiles of the shrimps fed with five different feeds were studied and the results were presented in Table 7. The results indicated the presence of 9 essential amino acids (arginine, histidine, lysine, threonine, methionine, leucine, isoleucine, valine and phenyl alanine). The highest average concentration of lysine 6.54 mg/100g was recorded in shrimps fed with wet reduction feed. On the other hand, low level of Leucine (1.09 mg/100g) was found in shrimps fed with traditional feed. Shrimps fed with dry reduction feed and traditional feed had low level of threonine (1.48,.09 mg/100g), industrial feed fed shrimps

Table 1: Ingredients used for Feed formulation

Wet reduction feed	Dry reduction feed	Traditional feed	Industrial feed	Quantity (g)
Wet reduction fishmeal	Dry reduction fishmeal	Traditional fishmeal	Industrial fishmeal	50
Soya bean meal	Soya bean meal	Soya bean meal	Soya bean meal	7
Tapioca	Tapioca	Tapioca	Tapioca	7
Broken rice	Broken rice	Broken rice	Broken rice	7
Ground nut meal	Ground nut meal	Ground nut meal	Ground nut meal	10
Wheat flour	Wheat flour	Wheat flour	Wheat flour	9
Rice bran	Rice bran	Rice bran	Rice bran	10

Table 2: Proximate composition of feed ingredients

Ingredients	Moisture	Protein	Lipid	Ash	Carbohydrate	Gross energy (kcal/100g)
Dry reduction FM	5.9 ±0.40	58.3±1.13	6.50±0.63	13.2±0.45	15.9±1.05	456.7±5.11
Wet reduction FM	5.80± 0.60	68.7±3.07	9.90±0.10	11.4±0.59	4.03±1.00	497.9±2.38
Traditional FM	16.54±0.86	32.9±0.90	4.83±0.73	14.6±0.36	31.0±1.00	358.8±0.51
Industrial FM	6.08±0.59	64.0±1.00	5.00±1.00	13.5±0.91	11.6±1.04	456.0±5.51
Soya bean meal	10.0±1.00	42.9±0.36	5.25±0.67	6.00±1.00	29.1± 0.96	411.3±3.78
Wheat flour	12.6±1.00	14.5±0.47	3.72±0.49	2.33±0.82	64.2± 0.75	380.5± 20.0
Rice bran	9.30±1.21	8.27±0.41	2.65±0.88	3.00± 1.00	58.2±1.00	309.9±1.70
Broken rice	10.0±2.00	12.0±1.00	4.23±0.25	3.15± 0.37	65.4±0.50	376.1± 3.53
GN meal	7.10±1.65	26.8±1.05	7.55±0.52	7.73±0.63[f,]	23.3±1.13	317.3± 2.08
Tapioca	8.00±2.00	1.83±0.76	1.37±0.23	0.17±0.11	86.2±0.97	376.7±2.74

Table 3: Proximate composition of experimental feed

Parameter (%)	Wet reduction feed	Dry reduction feed	Traditional feed	Industrial feed
Moisture	8.7±0.7	9.8±0.2	12.0±1.0	11.0±0.6
Protein	47.6±1.8	43.2±1.3	39.9±0.8	43.8±0.9
Lipid	9.8±.0.2	8.2±0.6	5.5±0.9	7.7±0.4
Carbohydrate	16.9±0.9	21.6±0.9	10.4±0.5	14.1±0.7
Ash	0.7±0.05	0.3±0.06	3.6±0.1	1.1±0.1
Gross energy (k cal/100g)	433.8±1.6	422.2±3.3	315±0.9	368.7±1.2

Table 4: Growth of *P. monodon* fed with formulated feeds

Feeds	Days of culture	Initial Weight (g)	Average daily weight gain (g)	Average Body Weight (ABW) (g)	Total weight gain (g)	Survival Rate (%)	Total feed (g)	Total weight (g)	FCR
Wet reduction (A)	140	3.5	0.26	37	33.5	80	385	296	1.3
Dry reduction (B)	140	3.5	0.2	27.4	25.2	80	329	219.2	1.5
Traditional (C)	140	3.5	0.14	20	21.5	80	368	184	2
Industrial (D)	140		0.21	30	27.3	80	348	240	1.45

Table 5: Water quality parameters of *P.monodon* fed with formulated feeds

Feeds	Salinity (ppt)	Dissolved oxygen (ppm)	pH	Temperature (°C)
Wet reduction feed (A)	25-26	5.5-6.0	7.8-8.0	27-31
Dry reduction feed (B)	25-26	5.5	7.8-8.3	28-30
Traditional feed (C)	25-27	5.5-6.0	7.8-8.3	28-31
Industrial feed (D)	25-26	5.5-6.0	7.8-8.4	28-31

Table 6: Biochemical composition of *Penaeus monodon* fed with different feeds (Dry weight basis except moisture)

	Bio chemical parameters (%) of *Penaeus monodon*					
Feeds	Protein	Lipid	Carbohydrate	Fiber	Ash	Moisture
Wet reduction feed	24.58±1.39	8.32±0.58	3.0±0.08	3.65±0.49	3.04±0.05	72.44±0.51
Dry reduction feed	21.41±1.22	7.21±0.70	2.89±0.16	5.53±0.49	2.18±0.31	76.30±0.93
Traditional feed	14.82±1.59	2.24±0.40	1.03±0.05	2.59±0.47	1.81±0.24	80.24±1.37
Industrial feed	22.17±2.89	5.72±0.75	2.80±0.90	3.67±0.34	2.44±0.49	74.86±0.24
Control feed	23.1±0.9	7.77±0.43	1.36±0.29	3.13±0.04	2.90±0.13	74.1±0.9

Table 7: Essential and non essential amino acids of P. *monodon* fed with five different feeds

Amino acid profile composition (mg/100g)					
Amino acids	Wet reduction feed	Dry reduction feed	Traditional feed	Industrial feed	Control feed
Essential Amino acids (EAA)					
Threonine	2.75±0.25	1.48±0.48	0.09±0.06	1.80±0.29	2.07±0.04
Valine	3.78±0.40	2.49±0.49	0.23±0.06	2.79±0.70	2.30±0.60
Arginine	6.49±0.98	4.52±0.43	00±00	4.28±0.49	4.97±0.06
Methionine	5.04±0.07	3.46±0.50	1.28±0.66	3.28±0.25	4.26±0.53
Isoleucine	6.21±0.73	4.72±1.11	1.50±0.5	4.43±0.36	5.12±0.68
Leucine	2.57±0.47	2.43±0.51	1.09±0.37	2.44±0.51	2.52±0.50
Lysine	6.54±0.54	5.25±0.36	2.26±0.53	5.34±0.57	5.34±0.57
Phenylalanine	5.58±0.44	4.55±0.48	1.50±0.5	4.58±0.38	5.33±0.58
Histidine	3.31±0.54	2.23±0.48	1.30±0.51	0.29±0.09	3.13±0.05
Total	42.27	31.13	9.25	29.23	35.04
Non Essential Amino acids (NEAA)					
Aspartic acid	4.93±0.39	4.17±0.47	1.99±0.01	4.74±0.36	4.45±0.55
Glutamic acid	5.42±0.52	3.84±0.39	1.76±0.41	3.05±0.04	4.71±0.29
Cystine	1.49±0.44	1.00±0.5	0.80±0.2	1.94±0.87	1.68±0.55
Tyrosine	2.44±0.49	2.09±0.86	0.49±0.04	1.55±0.42	2.50±0.48
Alanine	1.09±0.08	0.31±0.16	00±00	1.04±0.03	1.15±0.76
Glycine	2.73±0.50	2.52±0.46	0.34±0.14	1.77±0.37	2.41±0.53
Proline	2.97±0.23	1.50±0.5	0.21±0.10	1.48±0.48	2.81±0.27
Serine	3.73±0.30	3.20±0.22	1.11±1.11	3.22±0.67	3.12±0.12
Total	24.8	18.63	6.7	18.79	22.83

Table 8: Fatty acid contents of *Penaeus monodon* fed with five different feeds

	Fatty acid composition (%)					
Fatty acids	Carbon	Wet reduction feed	Dry reduction feed	Traditional feed	Industrial feed	Control feed
Leuric acid	C12:0	2.5±0.55	1.72±0.45	0.3±0.14	1.48±0.45	2.45±0.56
Myristic acid	C14:0	0.95±0.15	1.06±0.03	00±00	0.43±0.30	0.85±0.25
Palmitic acid	C16:0	2.7±0.43	1.6±0.45	1.11±0.06	1.14±0.09	1.8±0.34
Stearic acid	C18:0	0.78±0.05	0.62±0.21	0.10±0.09	0.27±0.10	0.68±0.08
Behenic acid	C22:0	1.67±0.57	1.26±0.56	0.33±0.09	0.96±0.069	1.33±0.58
Palmitoleic acid	C16:1n-7	2.28±0.57	1.95±0.44	0.25±0.08	1.33±0.58	2.0±1
Oleic acid	C18:1n-9	6.10±0.13	4.25±0.66	2.01±0.01	3.83±0.33	5.88±0.49
Nervonic acid	C24:1	4.71±0.13	2.53±0.50	0.07±0.02	0.31±0.04	0.64±0.26
Linoleic acid	C24:1	11.64±0.69	9.16±0.78	3.86±0.42	10.25±0.78	11.15±0.90
Linolenic acid	C18:2n-6	2.85±0.13	2.56±0.51	0.96±0.14	1.92±0.09	2.36±0.55
Arachidonic acid	C18:3n-3	3.38±0.54	2.81±0.32	0.35±0.11	2.76±0.41	2.85±0.28
Eicosapentaenic acid	C20:5n-3	11.13±1.02	9.82±0.30	1.44±0.48	8.13±0.66	7.65±0.6
Decosahexaenic acid	C22:6n-3	8.85±0.31	8.28±0.62	2.11±0.05	3.65±0.18	8.52±0.42

had low level of histidine (0.29 mg/100g) and traditional feed fed shrimp had below detectable level of alanine. Furthermore, Essential amino acid data showed that the traditional feed fed shrimp had lower contents of all essential amino acids than other feeds fed shrimps whereas wet reduction feed fed shrimps showed significant increase of the amino acids. The whole body composition of *P. monodon* had 8 non essential amino acids (Aspartic acid, glutamic acid, cysteine, tyrosine, alanine, glycine, proline and serine) and among these, Glutamic acid (5.2 mg/100g) and aspartic acid (4.93 mg/100g) had the highest concentration in all the shrimps while alanine had lowest level than other non essential amino acids.

Fatty acid profiles of the shrimps fed with different feeds are shown in Table 8. Shrimp meat had significantly higher proportion of unsaturated fatty acids, significantly lower proportion of saturated fatty acids and their content were in the following trend that the shrimps fed with wet reduction feed > dry reduction feed > industrial feed > traditional feed.

DISCUSSION

The choice of a feed ingredient is an additive in shrimp feed and is dependent on nutritional status, availability, cost, pelletability, palatability, stability during processing and storage [13]. Fish meal prepared by wet reduction, dry reduction, traditional and industrial method comprises of fishes with various preparation method. Feed ingredients of all other terrestrial ingredients were same. According to Dall [14], the complete feed which would supply all the nutrients such as protein, lipid, carbohydrate, vitamin and mineral are needed by the cultured animal for maximizing the growth. In the present study, using low cost ingredients and fishmeal was prepared in two different ways and the traditional and industrial fish meals were procured for the comparative analysis. All the four fish meals were taken and some terrestrial items were procured from the local grocery stores as proposed by Hertrampf and Piedad-Pascual [15]. Tacon [16] suggested limited use of plant ingredients in crustaceans feed because it is very hard to digest. Marine sources included fish meal, *Acetes*sp. and squid was used as a feed, because it is known to be highly digestible by crustaceans [17].

The proximate composition of feed stuffs may vary with season, geographic location, freshness of raw material and processing, so the result of the proximate analysis of ingredients only will give approximate value [18]. Hossain [19] reported that characteristic good feed ingredient had moisture content within the range of 15%. In the present study, the ingredients of feeds such as fish meal and other terrestrial ingredients were within the acceptable moisture limit of 15% whereas the ingredients of traditional fish meal were above the acceptable limit.

Protein is the major growth promoting factor in feed and the ingredients with above 50% protein was considered as protein ingredient and <20% is considered as non protein ingredient [20]. In the present study, >50% protein content was found in fish meals, ground nut oil cake and soyabean meal had 26.8 and 42.90% whereas the rest of the ingredients had <20% and this was in agreement with the findings of Kim and Easter [21]. Lipids present in the feed ingredients supply essential fatty acids which serve as a vehicle for absorption of fat soluble vitamins and precursors for steroid hormones [22]. In the present study, lipid content was high (9.9%) in wet reduction fishmeal and low in tapioca flour (1.2%). Carbohydrates form the major volume of all biological material which can be detected as Nitrogen free extract (NFE) [23] and available in terrestrial items as starch, glucose, cellulose whereas in animal it is present as glycogen. NFE was high in terrestrial items used in the formulated feeds where as it was low in fish meals [24] and it coincided with the present study. Ash is a group of mixed materials found in most feed stuffs and both should not be higher than 8 - 15%, because it leads to poor digestibility [25].

In the proximate composition of the feeds the declared moisture content of feed is 10 - 12% [26]. Except the traditional feed (13.1%), most of the formulated feeds in the present study had within the acceptable range of moisture. Increase of moisture content of the feed can affect the stability of the feeds in water and leads to low shelf life and susceptible to growth of microbes [27]. Proteins are continuously used by the animals to build new tissues and repair tissues and reduction in protein results in loss of weight [28]. The quantity and quality of protein in the feed is very important [29]. In the present study, protein level in diets varied from 39.9 to 47.6% and the lowest dietary protein level was still above the protein requirement of *P.monodon* except in traditional feed. Lipids are water insoluble biomolecules and are a source of fatty acids and attractants and the quality and quantity is important, however the levels does not exceed 10% in feed [30]. The percentage of lipid content for the best growth, efficient feed conversion and optimum survival rate of *P.monodon* was less than 10. Sivanandavel*et al.,* [30] reported that >10% lipid retards the growth and reduces the survival rate of *P. monodon.* In the present study and all the experimental feed did not exceed the lipid value of 10% and fulfilling the requirements of shrimp *P. monodon.* Ash is a group of soluble nature of mixed minerals and the acceptable limit in feed is10 - 25% [31]. In the present study ash content were acceptable limit in all the feeds except traditional feed. High content of ash reduces the digestibility of the diet resulting in poor growth of the animal [32]. Carbohydrates or NFE are low cost non protein energy source which can spare more expensive protein for growth and act as a binding agent to produce water stable feed and their limitation in feed is 50% and above this level leads to dietary accumulation of glycogen in liver causing death of the animal and can affect the carbohydrate digestibility [33]. Kavitha *et al.* [34] reported that carbohydrate requirement of fish from feed was 20% and for the shrimp, it was 35 - 45% and also reported that younger prawns require less carbohydrate than that of growing prawn because younger prawn requires high protein for energy and growth [35]. The present study results coincide with the above statements in the quantity of carbohydrate in feed. Gross energy (GE) is known as the total energy of feed and some are excreted via urine and faeces and remaining energy that is totally available to the animal known as metabolizable energy and this gross energy can be calculated from the proximate composition with standard value [36]. Basudha and Vishwanath [37] reported that higher protein content yield highest gross energy (474.52 k cal) compared to lower protein (417 k cal) and non protein diets (386 k cal) and the present study results coincide with the above statement because the gross energy content was high in higher inclusion of fishmeal of wet reduction feed compared to other feeds.

Shrimps are opportunistic omnivores that utilize different types of food items efficiently. The amount of feed offered should be regulated with reference to the body weight of the shrimp being cultured as well as observation on their daily feed intake [38]. Feed rate are expressed as percent of body weight per day (%BW/Day) but in the present study feeding rate was not constant throughout the experimental period. Lee and Wickins [39] recommended higher percentage body weight feeding (25-15%) for juvenile which reduced at progressed day. In the present investigation, all feeds were given to the shrimps based on the recommended (10% body weight) feeding rates for *P.monodon.* The number of meals offered daily and the time of feeding are factors that affect growth and feed efficiency. The total amount of feed to be offered each day is divided into multiple feedings and is spaced several hours apart which, improves the feed conversion ratios and growth rates [40, 41]. In the present study, the total amount of daily feed were divided into 4 and fed at 4 hours intervals such as 7 and 11 AM, 3 and 7PM. Soundrapandian and Raja [42] reported that combined feed ingredients of fish, mollusk and crustacean influence higher feed intake than that of individual feeds of fish. Present study results of wet and dry reduction feed agrees with above statement because in these fish meals composition of all seafood sources were incorporated and it was compared with industrial fishmeal formulated with single species of fish. Shrimps fed with the required amount of protein exhibited highest weight gain. Present study reveals that the wet reduction feed showed good results during the feeding trial with *P.monodon* and also indicated good health condition of the shrimp. Feed consumption decreased with the addition of fish meals produced from spoiled raw material [43] and presence of biogenic amines in feed causes reduced feed intake and this was proved in Salmonids [44] and in rainbow trout [45] and this was proved by the shrimps fed with traditional feed too. Frequent molting was observed during feeding experiment with wet reduction feed. Ali [46] reported occurrence of frequent molting is one of the common indicators for good nutritive survival of shrimp.

Feed consumption is always related with weight gain. In the present study shrimp consume more amount of wet reduction feed and fewer amounts of other feeds. So the weight gain was correspondingly higher in wet reduction feed fed animals. FCR is closely related to the quality of feed and the values less than 2.0 are considered good [47] and high FCR (>2) due to the results from nutritionally deficient feeds, overfeeding, poor water quality and crowding leads efficiency fall down. FCR value observed in the present study could be reasonably compared with the previous reports on *P. monodon* culture [48]. Survival rate estimation was based on daily counting of dead animals and final remaining number of live animals at the end of the experiment. In the present study, good survival (80%) was obtained and all the experimental shrimps were fed with experimental feeds. Krantz and Norris [49] stated that the survival rates of 60 to 80% are to be expected for *P. monodon*under suitable rearing conditions. According to Catacutan [17], a survival of more than 80% is usually considered as good for crustacean culture. After termination of 140 days culture period, average body weight (g) was high in wet reduction feed fed shrimps (37g) compared to, dry reduction fed shrimps (27.4g), industrial feed (30g) and were less for traditional feed fed shrimps (20g). Also the shrimps showed better weight gain of 33.5 g and specific daily weight gain of 0.26g for wet reduction feed shrimps. Total feed intake (385g) and weight gain (296g) also high with less FCR (1.3) was observed for the wet reduction feed fed shrimps but 368g feed was taken by the traditional feed fed shrimps with lesser weight gain of 184g with high FCR (2.0). Among the four feeds used for the study only the wet reduction feed is good for shrimp growth.

The maintenance of good water quality is essential for optimum growth and survival of shrimps. As per the report of MPEDA [50], in the present study, one tenth of the culture water in each tank was replaced every day. Filtered seawater pumped in to the tank was completely free from pollution and regular monitor was done for the mortality and any disease outbreak and excess feed and faecal matter also carefully removed to avoid disastrous effect on the growing shrimps. The optimum range of pH for *P.monodon* was noticed as 7.5 -7.8 [51]; 6.8 - 7.8 [52]. The optimum range of temperature for the *P.monodon* is between 28 to 30°C [41], 25 to 31°C[53]. In the present study, some time due to evaporation, salt concentration in tanks gradually increased so that distilled water was used to adjust filtered natural sea waters salinity as 25‰ and the salinity level of 15 - 35‰ was maintained in all the tanks. The oxygen content of the water, known as the dissolved oxygen (DO), plays an important role on the growth and production through its direct effect on feed consumption and maturation and must remain above a critical level in order to provide sufficient oxygen to the shrimp. Oxygen requirements in *P. monodon*has been defined to be optimally cultured at 4 - 7 ppm and critically stressed at and below 2.5 ppm [54]. Rosas *et al.* [55] reported fluctuation of DO noted in day and night in the extensive culture because of photosynthesis, but in intensive culture fluctuation was not varied and this was in agreement with the present study. In the present study the environmental parameter such as salinity, DO, pH, temperature were found in the range of 25 - 28 ppt, 5.5-6.0 ppm, 7.8 to 8.4 and 27- 31°C respectively for all the experimental tanks ideal for shrimp culture. In general salinity and temperature variations are considered the most important factors influencing the growth and survival of shrimp. It is likely that oxygen and pH have many additional impacts on the immune system of invertebrate. Low oxygen and pH suppress the activity of crustacean phenoloxidase activity [56].

The results indicate that the feed formulated with cheaply available nutritious ingredients and hygienically processed fresh trash fish feed is beneficial for the shrimp *P.monodon*. By using this low cost wet reduction feed, growth rate of shrimp was high with marketable size high and high efficiency could be produced within a short period.

Biochemical studies are important from the nutritional point of view. The biochemical constituents of the animals vary with season, size of the animal, stage of maturity, temperature, food availability etc. The feeds have positive influence on carbohydrate, protein, nitrogen and lipid metabolism in crustaceans [57] which were found to vary with times and species. In the present study, all the biochemical constituents of the shrimp *P.* monodon were altered significantly by the quality of feeds during the experimental study and the results are in agreement with the observations of Soundarpandian and Ananthan [58]. Karakoltsidis *et al*. [59] reported that feeds play an important role in the proximate composition of the finfish and crustaceans.

The whole body moisture content of the shrimps varied when they fed with different feeds in the present study. Nor Faadila *et al*. [60] reported that majority of shrimp usually consists of moisture within the range of 70 - 80% and it is similar to the results of the present study.Manivanan *et al.* [1] reported that moisture content of crab *S. serrata* was affected by the quality of feed. Maynard and Loosli [61] reported that moisture tends to decrease with an increasing nutrient content and this is in agreement with the present findings. O'Connor and Gilbert [62] reported that deficiency of nutrients uptake leads to longer inter molt period and results in very soft nature of shells and increase the moisture content in crustaceans is due to water uptake and this was supported with the observations from the results of traditional feed fed shrimps with increasing moisture content.

Protein is the major constituent in the muscle of shrimps. In the present study, protein content was higher in wet reduction feed fed *P. monodon* (24.58%) when compared to other feeds fed shrimps. These differences in the protein contents are statistically significant. Mona *et al.* [63] reported that high protein content in crustaceans' species can be attributed to be its feeding habit and the average body protein of the shrimp directly related to the level of the protein in the diet up to 75% and the finding are similar to the present observations. In the present study, except traditional feed fed shrimps (14.82%), the other experimental feed fed shrimps had more or less similar protein content of other peaneid species such as *P.indicus* [64] and wild *P.monodon* [65]. Rosas *et al.* [66] reported that the ingredients in the feed have some negative effect on the body protein levels. In the present study, protein content of the five experimental feeds had influenced the body protein content of *P.monodon*. Similar pattern of protein changes depends upon the feeds was reported in *P. monodon* [67].

Lim and Dominy [68] reported that there was no significant difference in the whole body composition of lipid, ash, calcium or potassium of *Peaneus vannamei* fed with different diets incorporated with a major ingredient of soya bean meal. Lipids are highly efficient source of energy and they contain twice the energy of carbohydrates and proteins and act as a major food reserves along with protein and the content were fluctuated depends upon the external factors such as temperature and internal factor of diet [69]. In the present study, lipid content of the wet reduction feed fed shrimps were higher (8.32%) than other feeds fed shrimps. Abulude *et al*. [70] reported that the lipid content varied from one shrimp to another, but the values were between 5.0 and 9.0% and it was in agreement with the present study except lipid content of traditional feed fed shrimps, an indication that the culture species very susceptible to feed quality. Catacutan [17] noticed that increased level of carcass lipid in *P. monodon* fed with a diet containing high lipid supplement. Croos *et al*. [71] reported that the lipid content of *P.monodon* was 6.6 – 7.7%. O'Leary and Mathews [72] reported that the lipid level of the wild and farmed *P. monodon* were dissimilar and was 4.35 and 8.66%. The whole body ash content of *P. monodon* in the present study was affected by diets because the contents varied with different feeds and similar result has been reported earlier in *P. monodon* [73]. USDA [74] reported higher moisture, protein, lipid and lower ash contents for wild and cultured *P.monodon* and it was similar to the results of the present study. Adeyeye [75] reported that high ash content is of significance in measuring the mineral content of the species as the amount of ash shows the richness of the food in terms of element composition. In the present study, ash content of shrimps fed with wet, dry reduction feed, traditional and industrial feed were 3.04, 2.18, 1.81 and 2.44% respectively. Sriraman and Reddy [76] observed slight increase in ash content with the increase in the size of *P. monodon*. Present study also had gradual rise in ash content of muscle and varied with size of animal.

In the present study, the whole body fiber content of the shrimps was affected by diet quality. The body fiber content is lesser than feeds and similar results have been reported for *P. monodon* [77]. High fiber content has got a nutritional advantage like assisting in reducing constipation and other attendant problems in the human consumers [70]. The fiber content of the fish was low (0.40 - 0.54%) and the content was high in crustacean (4.21- 4.34%) [78]. In the present study, the fiber content was above 2 - 3% in all the feed fed shrimp species.

Carbohydrates are non-protein compounds are also important constituents but are present in small amounts and are usually ignored during analysis. The shrimp species fed with five different feed has a carbohydrate content ranged from 1.03 - 3.0% and this was similar to that observed by Sudhakar *et al.* [79] in *Podopthalmus vigil* (1.57%) and in *P.monodon*(1.4–2.4%) [64]. The low carbohydrate content recorded in traditional feed fed animal in the present study is in agreement with the observations by Okuzumi and Fujii [80] who stated that faecal carbohydrate increased with decreased muscle carbohydrate. As with protein, the carbohydrate content of the feeds also influenced the body carbohydrate content of *P. monodon*in the present study. The result of Diaz and Nakagawa [81] indicated that dietary carbohydrate can influence the proximate composition of prawn. Manivannan *et al*. [1] reported that dietary carbohydrate level can affect the proximate composition of crab *S.tranquebarica*. Ajithkumar [82] reported that the raise in carbohydrate content was gradual among the size groups and the peak value was observed in the bigger size group, which may be due to more synthesis and accumulation of carbohydrates in the higher size groups than in younger ones and it was in agreement with the results of present study because carbohydrate fluctuation was noticed among the size groups of experimental shrimps and higher was observed in wet reduction feed fed animals.

Amino acids are the building blocks of proteins and serve as body builders. They are utilized to form various cell structures, of which they are key components and they serve as a source of energy [3]. The recorded data in the present study indicate the presence of 9 essential amino acids (arginine, histidine, lysine, theronine, methionine, leucine, isoleucine, valine and phenylalanine) and 8 non essential amino acids (aspartic acid, glutamic acid, cystine, tyrosine, alanine, glycine, proline and serine). O'Leary and Mathews [72] reported that in aqua cultured shrimp *P.monodon*, sixteen amino acids were detected and among these 9 were essential and 7 were non essential amino acids. Bhavan *et al.* [3] reported nineteen amino acids in *Macrobrachium rosenbergii* and among these, eleven are essential and eight are non essential amino acids. Hamdi [83] reported nine essential amino acids and nine non essential were in edible muscle of *Procambarus clarkia* and *Erugosquillamassavensis*. The different amino acids in flesh of crustacean species might be associated with the varying tastes as well as textural properties of meat of the crustacean's species [84]. According to Sikorski *et al.* [85] glycine, alanine, serine and threonine give tasty sweet and in the present study also considerable amount of those amino acids were noted in cultured *P.monodon* and it provided good nutritive value with taste. Simpson *et al*. [86] have found that there is a high level of glycine, proline, arginine and valine amino acid in fresh *P.monodon* shrimp meat and in the present study, high level of lysine, arginine, phenyl alanine, methionine found in meat of experimental shrimp *P. monodon*. The amino acids in the present study show considerable variation in proportion from different feeds fed animals. To be precise, trash fish wet reduction feed fed *P. monodon* tend to have high essential amino acid contents in muscles than trash fish dry reduction feed, single species industrial fishmeal made feed, traditional feed fed *P. monodon* and the results are in agreement with the finding of Bassey *et al.* [87]. Prasad and Neelekandan

[88] reported that the essential amino acid composition were higher in *P. monodon* and the total contribution was 36.82%, but in the present study, the essential amino acids contributed 42.27% in shrimp fed with wet reduction feed, 31.13% in dry reduction feed fed animal, 9.25% in traditional feed fed animal, 29.23% in industrial feed fed animal. This suggests that the quality of feed differences affect the amino acid composition of edible shrimp. The recorded data indicated that feed with good protein source with lots of essential amino acids are good for edible shrimp than the nutritionally imbalanced feed.

Shrimp lipid contains fatty acids which provide various health benefits to humans. Saturated fatty acids contribute to major proportion of fatty acid profiles of many species of fish [89], wild caught *P. monodon* [71], *S. serrata* [88] and *S. transquebarica* [1]. In contrast, the present study reveals only a minor proportion of fatty acid profile represented by saturated fatty acids in the cultured *P. monodon*. Also, the percentages of MUFA and PUFA recorded from *P. monodon* were considerably high compared to those of some other sea foods like fin fishes (*Sardinella* species), Crustaceans (*Penaeusindicus*), Mollusc (*Chicoreusramosus*) [89] and wild caught *P. monodon* [71]. The most biologically active PUFA viz, Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA) are reported to contribute to highest proportion of total n-3 PUFA in most species [89]. The same was evident from the present study and high values were noted for wet reduction feed fed animals. Also EPA and DHA contents recorded in the present study showed that content of EPA > the content of DHA which is a distinguished feature of crustaceans and mollusks [90]. The present study shows that the fatty acid profile of the intensive cultured shrimps was distinct between the feeds. The reason might be the differences in quality of feed used in the culturing practices. It is also evident that the crustacean fatty acid profiles are influenced by the changes in the nutritional composition of the diet and by changes in the dietary sources [91]. Among five feeds used in the present study, hygienically produced wet reduction feed fed shrimp showed higher percentage of nutrients compared with other feed fed shrimp and results proved diet effects the biochemical composition of intensive cultured shrimps.

CONCLUSION

The obtained results proved that the quality of feed was very important for the growth and good nutritive profile of the cultured shrimp. Overall study suggest that least cost fishes with hygienic preparation method is one of the good source of fishmeal development, including preparation of aquaculture feeds and it is easy to invest for small scale industries to improve their economic welfare.

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