Research Journal of Animal, Veterinary and Fishery Sciences _____ISSN 2320 – 6535
Vol. **5(3),** 1-8, March **(2017)** *Res. J. Animal, Veterinary and Fishery Sci.*

Development of nutritious chutney powder from shrimp head waste for better utilization to reduce environmental pollution

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Available online at: www.isca.in, www.isca.me
Received 16th February 2017, revised 10th March 2017, accepted 23rd March 2017

Abstract

Shrimp processing industries produce one third of its waste from head and shell of the shrimps. Objective of this research is to utilize the shrimp head for the development of a value added product for better utilization of the protein rich resource and to minimize the environmental pollution. The fine shrimp head powder was used for making protein rich value added shrimp chutney powder with the addition other ingredients and it had a protein content of 23.2%. The shelf life assessment of the chutney powder results revealed that the product was good until the end of assessment period (3 months) and it is safe for human consumption. Present study reports shows that it is possible to manufacture protein rich shrimp chutney powder using unutilized shrimp head wasted from processing centers. These head waste can be utilized by local fisher women for the preparation of value added products for their economic empowerment.

Keywords: Shrimp processing waste, Shrimp head chutney powder, Quality, Shelf life.

Introduction

Among all the industries available in Tuticorin district sea food industry is the highly developing industry in recent years. In Tuticorin seafood's are processed into frozen and dried forms and exported to several countries. The seafood processing industries mainly concentrate on crustaceans, fishes and cephalopods. Among the crustaceans prawns and crabs were being processed. Ten different species of prawns such as white shrimp (*Litopenaeus vannamei),* Tiger prawn (*Penaeus monodon*), white prawn (*Fenneropenaeus inidicus*)**,** flower prawn (*Penaeus semisulcatus*), pink shrimp (*Metapenaeus dobsoni*), brown shrimp (*Metapenaeus monoserous*), king *prawn* (*Metapenaeus affinis*), Kidy shrimp (*Parapenaeopsis stylifera*), bamboo flower prawn (*Penaeus canaliculatus)* and red ring shrimp (*Aristeus alcocci*) are used for processing and exported in huge quantities. Among these ten species only *Litopenaeus vannamei* is cultured and rest were sea caught resources. Now a day's shrimp processing has increased which leads to higher production of processing bio waste. Shrimp industries generate large amounts of shrimp bio-waste during processing; approximately 45 - 55% of the weight of the raw shrimp was discarded as waste during processing. The shellfish processing industry in India generates 8.5 million tons of shell waste per year[1] and it was increasing nowadays as the requirement was increased. Processing industries generates solid waste that can be high as 50 - 80% of the original raw material[2]. On a global basis, the shrimp processing industry produces over 700000 million tons of shell wastes[3]. Among the head and shell waste, the weight of head waste is more due to the presence of some meat and brain. Increasing production of inedible parts of shrimp is causing environmental problems as a result of uncontrolled dumping of the bio wastes. Environmental implication of traditional disposal methods of such waste coupled with the strengthening of environmental regulations in many countries has created an interest in alternative method for disposal / utilization of this waste. Thus attention must be paid for greater utilization of shrimp processing by-products in order to address such concerns[4]. Shrimp head and shell are a good source for protein[5]. Several studies concentrate on the utilization of shrimp waste as enzyme, nutrients and value-added products[6], natural antioxidant extraction from shrimp[7] and extraction of carotene protein[8], chitin[9], chitosan[8] development of poultry feed[10] and manure[11].

Sun drying is an ancient mode of preserving technique used for shrimp waste. This procedure has shown a very low hygienic control which tend to be used for animal consumption. Proper use of crustacean wastes allows recovery of value added products which are having potential applications in the field of food[12-14].

Value adding is traditionally defined as processing outside straight commodity sales; processors can gain income not only by further processing of shrimp but by supplying markets with targeted product forms. In general, outcome of value added products are always greater than fresh fin and shell fishes. The dual advantages of this study is to find a way for better utilization of low value fishery products for making protein rich convenience foods is the main outcome of value addition. However there is an increasing trend in the utilization of value added fish products as evidenced by their availability in modern super markets as well as malls which are becoming popular. These value added new products will be helpful for the

economic empowerment of Self Help Group (SHG) fisher women.

The aim of this research is the development of low cost and environment friendly techniques to utilize the shrimp head waste and to manufacture a food product for human consumption. Chutney powder is a powdered food which is well known among Asian countries. It is a popular side dish for breakfast and dinner items in parts of South East Asia. So far no attempt has been taken to formulate and develop this edible product or other value added products from shrimp head waste in this region. Considering the above facts, shrimp chutney powder was developed from unutilized shrimp head waste.

Materials and methods

Collection of raw materials: Shrimp heads were collected from a shrimp processing plant of Tuticorin. Shrimp heads were immediately iced with crushed ice in an insulated ice box and then brought to the laboratory. Shrimp heads were thoroughly washed with portable water for several times. They were dried in a hot air oven at 60^{o}C. Dried shrimp heads were powdered using mechanical blender and it was sieved and packed in glass bottle for storage.

Chemical quality evaluation of fresh and dried shrimp head wastes: The protein content of the fresh shrimp head was estimated by Lowry's method[15] and lipid by using gravimetric method of Folch *et al*.[16]. The ash content was measured by Clucas and Ward[17] method using Muffle furnace. The spoilage indicator of total Volatile base-N (TVB-N) was estimated using the Conway micro-diffusion method[18]. Analyses were made in three replicates. Minerals such as calcium, copper, iron and manganese were determined quantitatively by atomic absorption spectrophotometer method[19]. 500 mg of the samples were digested with 9 ml of concentrated Nitric acid and 1 ml of perchloric acid over low heat on a hot plate. Caution was taken to avoid charring during the digestion process. When the solution become near dryness added a small quantity of double distilled water was poured in to the flask and rinsed. Then it was filtered through a filter paper into 25 ml volumetric flask and made up the solution to 25 ml using double distilled water. The made up samples were transferred into polythene bottles and stored for further analysis in Atomic absorption spectroscope (AAS model Agilent GPC A932 ver. 1.1). Blank solution was also prepared in the same way with the reagents but without the sample.

Production of shrimp chutney powder and assessment of quality: The ingredients used for developing chutney power are listed in Table-1. For the preparation of chutney powder initially skinless black gram, garlic, Fenugreek, red chili and curry leaves were fried until the grams turn into golden brown colour and powdered. Then, the shrimp head powder was mixed thoroughly with the above mixture and finally, asafoetida and salt were added. The chutney powder was packed in airtight plastic containers and stored at ambient temperature. Its biochemical, microbial and organoleptic analysis was done monthly interval. Control chutney powder was prepared using all ingredients except shrimp head powder as above procedure. The biochemical quality of shrimp chutney powder was analyzed.

Sensory evaluation: A panel of nine members from SDMRI has done the sensory analysis of the chutney powder. Prior to testing, panelists were familiarized with the properties of shrimp chutney powder. Pretests were undertaken with selected samples to familiarize the panelists with the measurement procedure (Figure-1). Normally chutney powder is mixed with coconut oil and used as a side dish for breakfast items (Figure-2). So three bowls of shrimp chutney powder mixed with oil were supplied to each panelist to recognize every attribute. The appearance, colour, odour, taste texture and overall acceptability was determined by using hedonic scale of 1 to 9[20] and the dishes were rated as 9 for excellent, 6 for good and below 4 for poor or unacceptable range.

Figure-1: Chutney powder.

Figure-2: Chutney powder mixed with oil.

Shelf life study of shrimp chutney powder: Shrimp chutney powder was stored at refrigeration temperature (8°C) and room temperature (30°C) throughout the study period of 3 months and

its microbial quality was evaluated. The microbiological characteristics such as Total plate count (TPC) were enumerated by using plate count agar and Total fungal count (TFC) were enumerated using potato dextrose agar of APHA[21]. The pathogenic bacteria like *Coliforms*, *Salmonella* and *Vibrio* were enumerated by following the method of USFDA[22].

Results and discussion

In Tuticorin, totally ten species of shrimps were used for processing and among them only 4 species such as *Penaeus vannamei, Fenneropenaeus indicus*, *Penaeus affinis* and *Metapenaeus monoceros* were dominant. *Penaeus vannamei* is the cultured and rest of the three were sea caught shrimps so that *Penaeus vannamei* is used for processing throughout the year and rest of the shrimp processing were done except the fishing holiday's period (April 15th to May 30th). The quantity of head and shell waste were measured from the four dominant species from the plant during processing and the details were shown in Table-1. The wastage is low in cultured shrimp than sea caught shrimps and it is clear that head waste is more than the shell waste.

Table-1: Average weight of and its bio waste of the dominant shrimp species.

Species	Total weight of shrimp (g)	Weight of head waste (g)	Weight of shell waste (g)
Penaeus vannamei	24	8	2
Peneaus indicus	38	12.7	3.1
Penaeus affinis	25	9	2
Metapenaeus monoceros	31	8.3	1.6

The head and shell waste is dried and powdered for the preparation of shrimp head chutney powder. The ingredients used to develop the chutney powder are shown in Table-2. Higher inclusion of shrimp head powder with the other ingredients was done for shrimp head chutney powder.

The proximate compositions of fresh and dry shrimp head waste and shrimp heaad chutney powder are depicted in Table-3. The protein, lipid, ash and pH content of fresh shrimp waste were 18.4%, 6.37%, 9.11% and 7.0 respectively and all the same parameters were slightly lower in dried shrimp head waste where as in the shrimp waste chutney power all the parameters were higher and it is having very good nutritive value. The spoilage indicator TVB-N content was too low (0.002 mg/100g) in shrimp chutney powder than fresh and dried shrimp waste. One way ANOVA was performed that there was a significant difference ($P<0.01$) between fresh waste, dried waste and chutney powder from different biochemical parameters.

Table-2: Ingredients used to develop 1 Kg of shrimp head chutney powder.

Ingredients	Amount in grams
Skinless black gram (*Phaseolus mungo*)	250
Shrimp shell powder	400
Salt	10
Curry leaves	20
Red chili	100
Asafoetida	5
Fenugreek	100
Garlic	100

Table-3: Proximate composition of fresh shrimp head waste.

Parameters	Fresh waste	Dried waste	Chutney powder	F
Protein (%)	18.4 ± 1.2	17.6 ± 0.77	23.2 ± 0.8	30.8878**
Lipid (%)	6.37 ± 2.6	9 ± 1.00	9.13 ± 0.7	7.941704**
Ash (%)	9.11± 0.25	19.2 ± 0.2	19.7 ± 1.18	214.937**
pH	7.0 ± 0.00	7.1 ± 1.09	7.0 ± 0.00	5.2E-16^{NS}
TVB-N (mg N/100g)	7.32 ± 0.94	0.03 ± 0.01	0.002 ± 0.001	181.5313**

**- $p<0.01$; NS- Not significant ($>p0.05$).

Minerals such as calcium, iron, copper and manganese were assessed in the shell waste and the results are presented in Table-4. Among the four minerals calcium was high followed by iron, copper and manganese.

Table-4: Mineral content of dried shrimp head.

Minerals (mg/g)	Shrimps waste
Calcium	155 ± 4.00
Iron	42.11 ± 2.00
Copper	40 ± 2.00
Manganese	12.6 ± 2.2

The results of organoleptic characteristics are revealed in Table-5. There was no remarkable organoleptic characteristic change in the chutney powder prepared from shrimp head waste

powder initially and during the storage period. The appearance, flavor, taste and acceptance were excellent and scored good value of 9. The sensory scores of chutney powder remained within the acceptable limit throughout the storage period.

The shelf life analysis of shrimp chutney powder stored at different temperature is depicted in Table-6. The shrimp chutney powder stored in refrigerator (8^oC) and at room temperature (25 to 30^oC) for three months. Bacterial loads (CFU/g) in the shrimp chutney powder stored in refrigerator were too low to count throughout the storage period. The bacterial load of shrimp chutney powder stored at room temperature showed too low to count initially but bacterial growth at room temperature rapidly increased with the progress of storage time. On both the storage conditions fungal colonies and pathogens like *salmonella, Vibrio* and Coliforms were absent throughout the storage period.

Discussion: The basic reimbursement for the production of value added products as far as food is concerned include the functional and economical benefits related to quality and nutrition, convenience in the preparation and high sensory appeal at a reasonable cost. Value added products meet changing consumer life style requirements. It offers better utilization of different low value fishery products. Incorporation of other ingredients gives better quality and taste. Promotes employment, entrepreneur ventures and exporting. It also minimizes the importing of products. It provides greater convenience to consumer through decreasing preparation time and minimizing preparation steps. There are some disadvantages as well. Value addition requires skilled technology, attractive packing and refrigerated storage increases the cost of production but the advantages are more[23]. The development of sea food in the form of meals, snacks, side dishes, dessert and so forth flew to new heights in the beginning of late 1980s. In urban areas, due the changes in the life style of people "ready-to-serve" and "ready-to-cook" convenience fishery products are in great demand. Chutney powder is a popular side dish to breakfast and dinner items to the south Indian people.

Table-5: Sensory quality attributes of shrimp head chutney powder.

Storage temperature	8^oC				30^oC				
Months of storage	0	1	2	3	0	1	2	3	
Colour	9 ± 0.00	9 ± 0.00	9 ± 0.00	9 ± 0.00	9 ± 0.00	8 ± 1.00	8 ± 1.00	8 ± 1.00	P<0.05
Flavour	9 ± 0.00	9 ± 0.00	9 ± 0.00	9 ± 0.00	9 ± 0.00	8 ± 1.00	8 ± 1.00	8 ± 1.00	
Taste	9 ± 0.00	9 ± 0.00	9 ± 0.00	9 ± 0.00	9 ± 0.00	9 ± 0.00	8 ± 1.00	8 ± 1.00	
General appearance	Excellent	Excellent	Excellent	Good	Excellent	Good	Good	Good	
Overall acceptance	9 ± 0.00	9 ± 0.00	9 ± 0.00	9 ± 0.00	9 ± 0.00	9 ± 0.00	9 ± 0.00	9 ± 0.00	

Table-6: Microbial quality of the of the shrimp head chutney powder stored at different temperature.

Product	Storage temperature	Storage months	TBC (CFU/g)	TFC (No. of colonies/g)	*Vibrio*/25g	*Salmonella*/25g	Coliform MPN/100g
Shrimp chutney powder	8^o C	0	TLTC	-	Absent	Absent	Nil
		1	TLTC	-	Absent	Absent	Nil
		2	TLTC	-	Absent	Absent	Nil
		3	TLTC	-	Absent	Absent	Nil
	30^o C	0	TLTC	-	Absent	Absent	Nil
		1	1.2×10^2	-	Absent	Absent	Nil
		2	1.42×10^3	-	Absent	Absent	Nil
		3	1.7×10^4	2	Absent	Absent	Nil

TLTC - Too Low To Count.

Several methods exist to assess seafood quality and deterioration. However, there is much variation between species, as well as different products of the chemical, bacteriological, and sensory changes, depending on storage temperature and conditions whether the product is fresh or processed, and the type of processing that is carried out. In the present study, shrimp head wastes were used to develop shrimp chutney powder by simple preparation method. The profile for crustacean waste protein is excellent, the content of essential amino acids being significantly higher than the standards with sulfur amino acids which are is higher in soya bean meal and lower in fishmeal[24]. Khan and Nowsad[25] developed shrimp cracker (a type of crispy biscuit) enriched with shrimp shell protein. The moisture content of fresh shrimp head waste was s 66.23%. Ushakumari and Ramanujan[26] investigated that moisture of shrimp shell waste is 71.6% which is closely related to the value (66.23%) obtained in the present study. Lowering of moisture content in the present study was due to the lack of homogeneity of the sample. Fresh shrimp had 18.4% protein where as in dried shrimp head protein content was low and it was 17.6%. The nutritive value of shrimp head chutney powder was more as 23.2% of protein, 9.13% of lipid, 19.7% of ash and pH 7.0. The spoilage indicator TVB-N content in shrimp chutney powder was too low as 0.002 mg/100g than the fresh and dried shrimp head powder due to processing of other ingredients for the development of chutney powder. One way ANOVA was performed among the different biochemical parameters between fresh waste, dried waste and chutney powder and the results revealed that there is a significant difference ($P<0.01$). The protein content of this shrimp head wastes in this study is higher than that of processing waste from shrimp *Xiphopenaeus kroyeri*[27]. Previous study also showed that shrimp waste had high protein content with good amino acid balance and glutamic acid was the abundant amino acid in shrimp protein[28]. Prawn head waste had rich protein with essential amino acids[29,30] and the oil extracted from shrimp head contains polyunsaturated fatty acids (PUFA) essential for fish and shellfish[31,32]. The nutritive components such as protein and enzymes are the excellent source of shrimp head waste[4,33]. Lopez-Cervantes *et al.*[34] reported the protein content in the liquid hydrolysates of shrimp waste was 42% (dry weight), the lipid content in the lipidic paste was 42% (dry weight), while the raw chitin's content of protein and ash was 18% and 4% (dry weight), respectively.

The lipid content of shrimp chutney powder was slightly higher than that of fresh and dried shrimp shell powder because of the addition of good lipid source garlic[35]. The increased lipid content observed may be due to the absence of lipid oxidation and dehydration during the processing of raw materials. This result is agreed with the earlier work in dehydrated ribbon fish which reveals that there was a lipid oxidation during processing and storage[36]. Protein content in shrimp chutney powder was higher (23.2%) than fresh shrimp head waste (18.4%) and dried shrimp head waste (17.6%) and this increase was due to black gram (*Phaseolus mungo*) ingredient. The protein value of the gastropod *Pleuroploca trapezium* was 10.28% but the meat balls prepared using same gastropod meat with corn flour and potato had 16.044 % of protein and it was mainly due to the ingredients used for the preparation of the meat balls[37]. In the case of octopus meat balls prepared using Bengal gram flour and smashed potato shows a slight increase in protein and lipid content due to the ingredients[38]. Shrimp head has higher content of fat and reducing sugar but lower protein content than shrimp meat. The proteolytic enzyme activities are concentrated in the midgut gland. Shrimp head waste is the rich source of chitin and also good source of protein, nutritive components and enzymes, making use of such wastes has drawn much more interest from researchers in recent years. Sopanodora and Buckle[39] reported the protein content in shrimp heads was quite high compared to the reported range of 8.9 - 23.2% in whole shrimp[40] but, fat content was lower than 5% therefore it could be categorized as low fat. Lopez-Cervantes *et al.*[34] reported crustacean heads and shells constitute of the shrimp wastes contain $17.66 \pm 0.13\%$ of protein, and $11.40 \pm 0.47\%$ of total lipids. TVB-N of the shrimp heads was less than 20mg N/100g, thus the raw material was considered fresh. TVB-N is often used as an index to assess the quality and shelf life of sea food products[41]. The TMA-N production was dependent on the bacterial activity[42]. Bacterial and endogenous enzymes present in food produce TVB-N which includes TMA, DMA and ammonia[43]. TVB-N is one of the most ammonia indices of quality universally. The acceptable limit of TVB-N for fishery products is 35 – 40 mg / 100g[44]. In the present study, the TVB-N observed was not high in fresh and dried shrimp head waste than in the chutney powder.

To identify the undesirable bacteria pH plays an important role[45]. The pH level of 7 is good for the edible product. In the present study neutral pH was observed in the final product indicates no microbial contamination in this product. Mineral content can be identified by measuring ash content of the sample. Shrimp shells are having 31 - 36% of ash[46]. In the present study fresh shrimp head contain 9.11% ash and dried shrimp head contain 19.2% of ash and shrimp chutney powder had 19.7% ash content. Experimental data shows that after the processing ash content was increased in the final product due to the addition of other ingredients. Edible products are having the acceptable limit of ash content of 20%[47]. In the present study 19.7% ash content was found in chutney powder and the results clearly indicates the chutney powder is one of the good nutritional supplements to the human being.

Among the four minerals calcium was high followed by iron, copper and manganese. The amount of calcium was found to be highest in shrimp head waste and the results coincided with the results of Khanafari *et al.*[48]. The shrimp head waste contains mineral content with the range of 12.6 - 15.5 mg/g. Calcium is present plenty in shrimp head waste. Hansen and Illanes[24] and our results were agreed as they suggest that the major mineral component of shellfish waste is calcium Beaney *et al.*[45] reported that calcium was abundantly present in prawn shell which is 17 times more than the magnesium. Synowiecki and Al-Kateeb[49]

stated that the minerals fraction of shrimp shells composed mostly of Iron, copper, calcium and manganese. Mahmoud *et al.*[50] reported the amount of iron and copper present in the *Penaeus semisulcatus* shells was 39.7 and 57 mg/g and it was agreed with our results.

Based on the results of organoleptic chraracteristics study, the prepared chutney powder had good desirable colour, texture, odour and flavour. Along with shrimp head powder, black gram, garlic and curry leaves were added to give additional taste and nutrition. When comparing both the chutney powders the shrimp chutney powder has high nutritional value. It increases the sea food taste without increasing the price on making the chutney powder. Two way ANOVA showed that there is a significant difference ($P<0.05$) between organoleptic parameters from different storage months stored in 30^{o}C storage temperature. The overall appearance, color, odor, taste and texture of the product determine the acceptability of the fishery product. The scientific description used for sensory evaluation is based on the interpret reaction of food as perceived through the senses of sight, smell, taste, touch and hearing[51]. The sensory judgment of the products prepared from shrimp shell waste was carried out by serving products to the people and the overall acceptability was determined using hedonic scale of 1 to 9[20]. Products with scores below 4 were considered unacceptable. All characters showed increase in organoleptic score during storage. In case of shrimp chutney powder, it had a good odor, taste, texture and flavor and good sensory score and it also remained within the acceptable condition. The appealing appearance of the shrimp head powder with longer shelf life found to be good and it can be used as a new ready to eat product for consumers. The sensory score for the horse conch, *Pleuroploca trapezium* meat ball decreased gradually during the storage period, but even after 10 months of frozen storage the score were well above the acceptability limit of 5[52]. The sensory score for the shrimp chutney powder do not decreased during the storage period even after the 3 months of refrigerated storage scored 9. But in ambient temperature stored shrimp chutney powder decreased gradually during the storage period, but even after 3 months of ambient storage the score were well above the acceptability limit of 5 and good in general appearance.

Chutney powder stored under both refrigerated and ambient conditions for about 90 days maintained the original quality of the powder. The microbiological quality of a material is linked to the level of hygiene in the production process. The results of the microbiological analysis in shrimp chutney powder as a result of no bacterial development for the identification of *E. coli, Salmonella,* Coliform and *Vibrio*. Fungus was detected in ambient stored chutney powder and it was 2 numbers of colonies per gram. The storage studies were conducted for three months, best results such as absence of bacteria, fungi and pathogenic bacteria were observed throughout the storage period in the refrigerated (8^{o}C) samples. Slight increase of bacterial population was observed in the chutney powder stored at ambient temperature. Microbial count of shrimp chutney powder was 1.7 x 10^4 CFU/g, which was below the microbiological quality parameter of 5, 00,000 TPC/g in sea foods[53], whereas the TPC of 8^{o}C stored shrimp chutney powder did not exceed the statistically acceptable limit of 25 - 250[54] and thus expressed as TLTC (Too Low To Count). During the third month of storage only 2 number of fungal colonies/g were observed with the absence of pathogens. Fungal colonies were not observed in the refrigerated chutney powder. Moisture is the key parameter for the growth of fungai which is reported by Rao *et al*. This fugal growth was indentified in fish and fishery products[55]. The moisture content of both the temperature stored chutney powder was low and this adequately prevented the fungal growth. Coliforms contamination is an indicator for faecal contamination and it was acceptable in food products 20/g[53] and in the present study coliforms was completely absent in shrimp chutney powder. The absence of pathogens like *Salmonella* and *Vibrio* were observed in shrimp chutney powder and similar report was found in squid *Sepioteuthis lessoniana* soup powder[56]. Seafood safety does not approve the presence of pathogens in sea food. This study reveals chutney powder stored in refrigerator (8^{o}C) can be able to withstand for 3 months without any sensorial changes while one month storage is suitable at ambient temperature (30^{o}C). The prepared flakes using *Chicoreous ramosus* and *Pleuroploca trapezium* stored for a period of 120 days remained without any spoilage[57]. In the present study, shrimp chutney powder was found to remain in good condition for 3 months in ambient storage condition.

Conclusion

In the present study innovative chutney powder was developed using shrimp head waste. Purpose of our research is to find a new way for the utilization of shrimp head for the development of a value added product, chutney powder, not only to eliminate pollution but also to increase the economy. Empowerment of self help group women has lead to the increased small scale production of new value added items so that SHG women will train in the development of chutney powder using shrimp head waste so will help in economic improvement of women and will reduce environmental pollution.

Acknowledgement

The authors are thankful to Dr. J.K. Patterson Edward, Director, Suganthi Devadason Marine Research Institute, India for providing us the facilities to carry out the work.

References

1. Clucas I.J. and James D.G. (1997). Papers presented at the Technical Consultation on the Reduction of Wastage in Fisheries. Tokyo, Japan 28 0ct.-1 Nov. 1996. *FA0 Fish*. Report No. 547 Suppl. 338. Rome.

2. Anon (2005). Assessment of harvest and post harvest losses in marine fisheries. CIFT Publication, Central Institute of fisheries technology, Cochin. 122.

3. Nowsad A. (2005). End of assignment report-Marine fish processing and product development. *Food and Agriculture Organization of the United Nations, Dhaka*, 77.

4. Heu M.S., Kim J.S. and Shahidi F. (2003). Components and nutritional quality of shrimp processing by-products. *Food Chem.* 82(2), 235-242.

5. Shahidi R. and Synowiecki J. (1991). Isolation and characterization of nutrients and value-added products from snow crab (*Chinoecete sopilio*) and shrimp (*Pandalus borealis*) processing discards. *J. Agri. Food Chem.* 39(8), 1527-1532.

6. Doke S.N. and Ninjoor V. (1987). Characteristics of an alkaline proteinase and exopeptidase from shrimp (*Penaeus indicus*) muscle. *J. Food Sci.,* 52(5), 1203-1208.

7. Pasqual L.J.R. and Babbitt J.K. (1991). Isolation and partial characterization of a natural antioxidant from shrimp (*Pandalus jordant*). *J. Food Sci*., 56, 143-145.

8. Simpson B.K. and Haard N.F. (1985). The use of proteolytic enzymes to extract carotenoproteins from shrimp processing waste. *J. Appl.Biochem.,* 7(3), 212-222.

9. Johnson L. (1987). Recovery of pigments and chitin from pink shrimp peeling wastes. Abstracts of Papers of the American Chemical Society, Amer Chemical Soc, 194, 100.

10. Benjakul S. and Sophanodora P. (1993). Chitosan production from carapace and shell of black tiger shrimp (*Penaeus monodon*). *Asian Food J.,* 8, 145-150.

11. Cano-Lopez A., Simpson B.K. and Haard N.F. (1987). Extraction of carotenoprotein from shrimp process wastes with the aid of trypsin from Atlantic cod. *J. Food Sci.* 52(2), 503-506.

12. Cira L.A., Huerta S., Hall G.M. and Shirai K. (2002). Pilot scale lactic acid fermentation of shrimp waste for chitin recovery. *Process Biochem*., 37(12), 1359-1366.

13. Khor E. and Lim L.Y. (2003). Implantable applications of chitin and chitosan. *Biomaterials*, 24(13), 2339-2349.

14. Santos S.D., Cahu T.B., Firmino G.O., De Castro C.C., Carvalho L.B., Bezerra R.S. and Filho J.L. (2012). Shrimp waste extract and astaxanthin: Rat alveolar macrophage, oxidative stress and inflammation. *Journal of Food Science*, 77(7), 141-146.

15. Lowry O.H., Rosebrough N.J., Farr A.L. and Randall R.J. (1951). Protein measurement with the folin phenol reagent. *J. Biol. Chem*., 193(1), 265-275.

16. Folch J., Lees M. and Stanley G.H.S. (1956). A simple method for the isolation and purification a total lipids from an animal tissues. *J. Biolo.chem*, 226(1), 497-509.

17. Clucas I.J. and Ward A.R. (1996). Post-harvest fisheries development. *Processing and quality*, NRI, ODA Kent, UK.

18. Beatty S.A. and Gibbons N.E. (1937). The measurement of spoilage in fish. *J. Biol. Board. Can.,* 3(1), 77-91.

19. AOAC (Association of Official Analytical Chemists) (1990). Official Methods of Analysis of the Association of Official Analytical Chemists. Thirteenth Edition. Association of Official Analytical Chemists (publisher), Washington, DC 20044, USA, 1018.

20. Amerine M.A., Pangborn R.M. and Rocssler E. (1965). Principles of sensory evolution of foods. 349, Academic press, New York.

21. Flowers R.S., Vanderzant C. and Splittstoesser D.F. (1992). Compendium of methods for the microbiological examination of foods. 3rd ed., APHA, Washington DC.

22. Andrews W.H., June G.A., Sherrod P.S., Hammack T.S. and Amaguana R.M. (1995). FDA Bacteriological analytical manual. AOAC International Gathersburg, USA., 614.

23. Selvaganapathy E. and Krishnan L. (2015). Production of fish value added items helping on livelihood enhancement of fisherwomen of Poompuhar, Sirkazhi Taluk, Nagapattinam District in Tamil Nadu, India. *Research Journal of Animal, Veterinary and Fishery Sciences,* 3(6), 1-4.

24. Hansen M.E. and Illanes A. (1994). Applications of crustacean wastes in Biotechnology. In Fisheries Processing, 174-205.

25. Khan M. and Nowsad A.K.M.A. (2012). Development of protein enriched shrimp crackers from shrimp shell wastes. *J.Bangladesh Agricultural University,* 10(2), 367-374. Date Retrieved: May 16, 2016. http://ageconsearch.umn.edu/bitstream/209727/2/14930-54304-1-PB.pdf.

26. Ushakumari U.N. and Ramanujan R. (2012). Astaxanthin from shrimp shell waste. *International journal of pharmaceutical chemistry research*, 1(3), 1-6.

27. Holanda H.D.D. and Netto F.M. (2006). Recovery of components from shrimp (*Xiphopenaeus Kroyeri*) processing waste by enzymatic hydrolysis. *J. Food Sci.,* 71(5), 298-303.

28. Ibrahim H.M., Salama M.F. and El-Banna H.A. (1999). Shrimp's waste: Chemical composition, nutritional value and utilization. *Molecular Nutrition & Food Research*, 43(6), 418-423.

29. Forster J.R.M. (1975). Studies on the development of compounded diets for prawns. *Proceedings of the First International Conference on Aquaculture Nutrition* (Price, K.S., Jr, Shaw, W.N. & Danberg, K.S. eds), 229-248. Delaware Sea Grant College Program and US/Japan Aquaculture Panel, College of Marine Studies, University of Delaware, Newark, NJ, USA.

30. Penaflorida V.D. (1989). An evaluation of indigenous protein sources as potential component in the diet formulation for the tiger prawn *Penaeus monodon* using essential amino acid index. *Aquaculture,* 83(3-4), 319-330.

31. Joseph J.D. and Meyers S.P. (1975). Lipid fatty acid composition of shrimp meals and crustacean diets. *Feed stuffs*. 47(35), 28-29.

32. Joseph J.D. and Williams J.E. (1975). Shrimp head oil: a potential feed additive for mariculture. *Proc. Symp. World Maricult. Soc*., 6, 147-152.

33. Fanimo A.O., Oduguwa O.O., Onifade A.O. and Olutunde T.O. (2000). Protein quality of shrimp-waste meal. *Bioresource Technology,* 72(2), 185-188.

34. Lopez-Cervantes J., Adan-Bante N.P. and Sanchez-Machado D.I. (2010). Separation and biochemical characterization of the products from fermented shrimp wastes. Sea By-Products as Real Material: New Ways of Application, 117-132. Editor: Estelle Le Bihan.

35. Potjanan R., Yardrung S. and Jirapa H. (2014). Chemical and Microbiological Changes during Shrimp Seasoning Fermentation Using Seafood Processing Waste. 3rd International Conference on Nutrition and Food Sciences IPCBEE, IACSIT Press, Singapore. V71. 11.

36. Jeevanandam K., Venugopal V., Doke S.N., Rao B.Y.K. and Bongirwr D.R. (2001). preparation and storage characteristic of ribbon fish laminates. *J. Aquatic. Food. Prod. Techno.,* 10(4), 77-86.

37. Shanthini F. and Patterson Jamila (2005). Processing of horse conch, Pleuroploca trapezium (Fasciolariidae) meat into meat balls. *Asian Fisheries Science*, 18(3), 265-273.

38. Chacko Ditty and Patterson Jamila (2011). Qualities of octopus meat balls developed using smashed potato and Bengal gram starches. *World Journal of Dairy and Food Sciences*, 6(2), 130-135.

39. Narkviroj P. and Buckle K. (1987). Utilization of prawn head powder in oriental prawn crackers. *ASEAN Food Journal*.

40. Chotiyanavong A. (1981). Analysis of fishery products. Bangkok: Kasetsart University, (In Thai).

41. Hebard C.E., Flick G.J. and Martin R.E. (1982). Occurrence and significant of tri methyl amine oxide and it derivatives in fish and shellfish. In chemistry and biochemistry of marine food products, Martin, R.E., (Editors), Connecticut, AVI publishing co., 149-304.

42. Beatty S.A. and Gibbons N.E. (1937). The measurement of spoilage in fish. *Journal of the Biological Board of Canada*, 3(1), 77-91.

43. Lannelongue M. (1980). Storage characteristics of fresh fish packed in modified atmosphere containing Co_2. Master's thesis, Texas A and M University college station TX, USA.

44. Kimura K. and Kiamukura S. (1934). Detection of the onset of decomposition of fish meat as shown by the content of Ammonia. *Proc. Pac. Sci. Congr.,* 5, 3709.

45. Beaney P., Mendoza J.L. and Healy M. (2005). Comparison of chitins produced by chemical and bioprocessing methods. *J. Chem. Technol. Biotechnol.*, 80(2), 145-150.

46. Bough W.A., Salter W.L., Wu A.C.M. and Perkins B.E. (1978). Influence of manufacturing variables on the characteristics and effectiveness of chitosan products. Chemical composition, viscosity, and molecular weight distribution of chitosan products. *Biotechnol. Bioeng*., 20(12), 1931-1943.

47. No H.K. and Meyers S.P. (1995). Preparation and characterization of chitin and chitosan-a review. *J. Aquat. Food Prod. Tech.,* 4(2), 27-52.

48. Khanafari A., Marandi R. and Sanatei S.H. (2008). Recovery of chitin and chitosan from shrimp waste by chemical and microbial methods. *Iran. J. Environ Sci. Eng,* 5(1), 19-24.

49. Synowiecki J. and Al-Khateeb N.A.A.Q. (2000). The recovery of protein hydrolysate during enzymatic isolation of chitin from shrimp *Crangon crangon* processing discards. *Food Chem,* 68(2), 147-152.

50. Mohmoud B.S.M., Kawai Y., Yamazaki K., Miyasita K. and Suzuki T. (2007). Effect of treatment with electrolyzed NaCl solutions and essential oil compounds on the proximate composition, aminoacid and fatty acid composition of carp fillets. *Food Chem.,* 101(4), 1492-1498.

51. Joseph A.C. (2003). Coated fish products for export and domestic markets. In: Seafood safety (Surendran, P.K., P.T. Mathew, N. Thampuran, V.N. Nambia, Joseph, M.R. Boopenranath, P.T. Lakhmanan and P.G.V. Nair, Eds), pp: 12, SOFT (I) Cochin, India.

52. Shanthini F.C. (2003). Value added products from underutilized marine Gastropod, *Pleuroploca trapezium* (Mollusca: Gastropoda: Fasciolaridea). M.S University thesis.

53. Surendran P.K., Thampuran Nirmala, Nambiar V. and Lalitha K.V. (2006). Laboratory manual on microbiological examination of seafood. CIFT, 2nd Edition.

54. USFDA (1998). Bacteriological Analytical Manual. 8th Edition, Revision A. AOAC International, Gaithersburg, MD.

55. Garm R. (1982). Reference Manual to codes of practices for fish and fishery products. 152, FAO, Rome.

56. Chacko Ditty, Emilin R. and Patterson Jamila (2005). Development of soup powder from squid Sepioteuthis lessoniana and shelf-life assessment during storage in laminated packaging material. *Journal of Food Technology*, 3(3), 449-452.

57. Patterson Jamila and Ayyakkannu K. (1997). Pickled product from gastropod, Babylonia spirata*. Fishery Technology*, 34(1), 45-48.