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Quality Evaluation of Spray-Dried Shell Protein Derived from Flower Tail Shrimp (*Metapenaeus dobsoni)*

U. Lakshmi Seethl[1], A. Jeyakumari[2], U. Parvathy[2] and A. A. Zynudheen[2]*
[1] *Kerala University of Fisheries and Ocean Studies, Panangad, Cochin - 682 506*
[2] *ICAR- Central Institute of Fisheries Technology, P. O. Matsyapuri, Cochin - 682 029*

Abstract

The current practice for the utilization of shrimp waste is mainly for the extraction of chitin and chitosan. However, during production of chitin, protein present in the shells are not utilized properly and it can be recovered mechanically. In the present study, the shrimp shell protein was extracted from *Metapenaeus dobsoni* by mechanical process and spray dried. The proximate composition and chemical quality parameters (TVBN, TMAN, PV, FFA, and TBA) of shrimp shell, Shrimp Shell Protein Solution (SSPS), and spray-dried Shrimp Shell Protein Powder (SSPP) were evaluated. Functional properties such as foaming capacity, foam stability, water absorption capacity, oil absorption capacity, hygroscopicity, and flow properties of SSPP were also investigated. The TVBN, TMAN, PV, FFA, and TBA values of shrimp shell, SSPS, and SSPP were found to be within acceptable limits. Higher protein content was found in SSPP (57.26±0.50% on wet basis) than in SSPS (8.95±0.18% on wet basis), the result suggested that SSPP can be incorporated as a good source of protein in food products.

Keywords: Spray-drying, shrimp shell protein, *Metapenaeus dobsoni*, chemical composition, functional properties

Introduction

Shrimp is considered the most popular species of seafood product for human consumption in many countries. Shrimp has received attention for human consumption because it is rich in lipids, proteins, minerals, and vitamins (Larsen et al., 2011). The global crustacean catch reported during the year 2020 was 5,625 thousand tonnes, live weight (FAO, 2022). During shrimp processing, large quantities of waste are generated in the form of head and carapace. According to MPEDA (2020) around 1.8 lakh tonnes of shrimp processing waste were produced in India during the year 2019. During shrimp processing, large quantities of waste are generated in the form of head and carapace, which comprises a fair amount of biomolecules like chitin, protein, fat, minerals, astaxanthin, etc. The most common methods for shrimp waste disposal are land filling, incineration, and dumping in the ocean; however, a small quantity is used for chitin extraction. Nevertheless, the current practice for the utilization of shrimp waste is the extraction of chitin but it can be additionally used as a source of protein. The chemical extraction of chitin causes the wastage of a large quantity of protein. The head and shell of shrimp comprise a fair amount of biomolecules like protein, fat, and minerals (Ibrahim et al., 1999). Protein can be separated from shrimp shells by mechanical separation or enzymatic digestion which allows the recovery of protein for the production of functional food products.

The major challenge is the utilization of the sensitive bioactive compounds obtained from the shrimp waste, without affecting their properties. Drying is an excellent method to protect these biomolecules recovered from shrimp waste which increases the shelf life of the food products and provides convenience. Freeze- drying and spray drying are the commonly used method for drying protein solution (Haque, 2014). The spray drying technique is a well-established method for drying protein solution, it has the advantages of high quantity production, hygienic, fairly simple process, and is having a desirable particle size range (Jayasundera

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**Email: zynucift@gmail.com*

et al., 2010). *Metapenaeus dobsoni* is mostly found in the west and east coast of India and its seasonal availability is from July to October. Considering the importance of protein from shrimp shell, many of the researchers attempted to recover the protein from shrimp shell by enzymatic method (Gunasekaran et al., 2015; Rios et al., 2017) which is a time consuming process with high cost. Since, the extraction of protein by mechanical pressing method does not involve any harmful chemicals it can be considered as a green extraction technique which is cost effective. The extraction of protein from *Metapenaeus dobsoni* shell waste by mechanical separation and its properties are not yet studied. Hence, the present study was intended to recover the protein from shrimp (*Metapenaeus dobsoni*) shell by mechanical separation followed by spray drying and to assess its biochemical and functional properties.

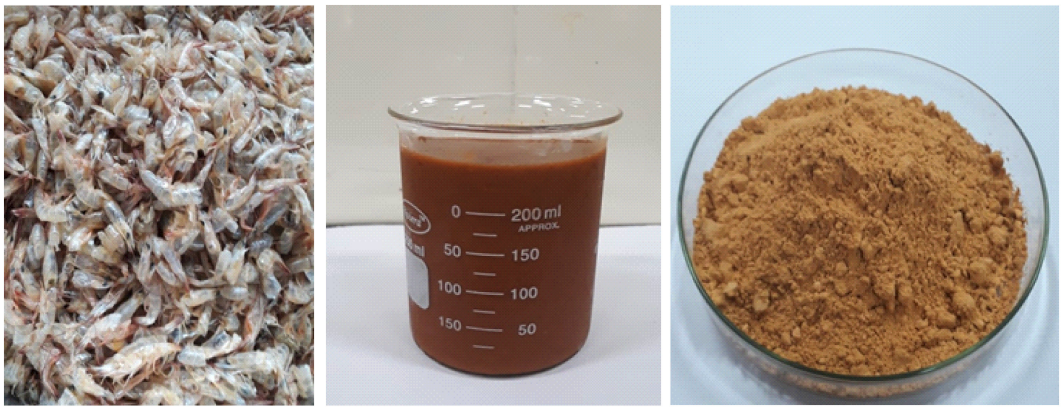
Material and Methods

Metapenaeus dobsoni caught on board ICAR CIFT vessel of Kochi Kerala was iced immediately and brought to the laboratory of Central Institute of Fisheries Technology (CIFT) Kochi, Kerala. On reaching the laboratory (within 2hrs) the sample was washed thoroughly in potable chilled water two times and finally washed with 2ppm chlorine water. After washing, shell was separated from the meat and immediately used for the extraction of protein.

The shrimp shell was instantly passed through the mechanical device for protein recovery. The protein solution obtained was homogenized using a tissue homogenizer (IKA ® T18 Digital Ultra Turrax) at 10000 rpm for 5 min. Then it was filtered through muslin cloth and was subjected to spray-drying (Fig.1) using a pilot-scale spray dryer (SMS Scientech, Machin no 16, Kolkata, India) under the following spray-drying conditions: inlet temperature of 160°C, outlet temperature 80°C, nozzle diameter 0.5 mm, air pressure 2kg/cm^2, and spray flow feed rate 17-19mL/min. The protein solution was coded as SSPS and spray-dried shrimp shell protein powder was coded as SSPP. Both the samples were analyzed for various quality parameters.

Proximate composition (moisture, protein, fat, and ash) of shrimp shell, shrimp shell protein solution, and shrimp shell protein powder were determined according to AOAC (2019) method. The pH was determined by mixing the 5g sample in 25 ml distilled water and measured the pH using a Cyberscan pH meter. Total volatile base nitrogen (TVBN) and Trimethylamine (TMA)were measured according to (Conway, 1962). Thiobarbituric acid (TBA) value was determined using the method described by Tarlandgis et al. (1960) and expressed as mg malondialdehyde kg^{-1}. The free fatty acids (FFA) were determined as per AOAC (2019) method and expressed as % of oleic acid. The peroxide value (PV) of the lipid content was estimated by the acetic acid–chloroform method described in AOAC (2019) and expressed as meq.O_2 kg^{-1} lipid.

The shrimp shell protein powder (SSPP) was subjected to physical and functional properties assessment. The bulk density and tapped density were determined by the method described by Chinta et al., (2009). Carr's index and Hausner ratio were determined as described by Turchiuli et al.,



Shrimp shell Shrimp shell protein solution Shrimp shell protein powder

Fig. 1. Production of shrimp shell protein powder

(2005). Hygroscopicity of the powder was analyzed as g of water absorbed/100 g of dry solids (Murthy et al., 2017). Water absorption capacity (WAC) and oil absorption capacity (OAC) were evaluated according to Shahidi et al. (1995). The foaming capacity and foaming stability of SSPP were evaluated by the method followed by Sathe & Salun (1981). Briefly, 1% SSPP solution was homogenized at a speed of 16,000 rpm for 2 min. The foaming capacity was calculated immediately and after 3 minutes, the foaming stability was recorded. The color of spray-dried SSP was determined by using the Hunter Lab coloranalyzer (ColorFlex-EZ, s/n CFEZ 0257) and recorded as L^* for lightness, a^* positive values indicate redness and negative values indicate redness or greenness, and b^* for yellowness.

Results and Discussion

The proximate composition of shrimp shell, SSPS, and SSPP are presented in Table 1. Shrimp shells, SSPS, and SSPP were found to have very good nutritional contents and high levels of protein. The results are in well agreement with Gunasekaran et al.(2015) who has found 13.01 ± 0.04% crude protein on a wet weight basis in the head waste of *Metapenaeus dobsoni*. These analyses were well agreed with the findings reported by other investigators on other shrimp species (Shahidi, 1995; Nargis et al., 2006). A higher value of protein was noticed in the SSPP than that of SSPS. The average protein content in the whole shrimp waste powder reported by Khan et al. (2014) was about 45.2±1.3% on dry weight basis. The lipid and ash content of SSPP was found to be high as compared to shell and SSPS. The lipid and ash content of SSPP was found to be high as compared to shell and SSPS. Khan et al. (2014) observed high value of lipid (10%) and ash (19.6%) on dry basis for dried shrimp shell. Gunasekaran et al., (2015) observed the lipid and ash content of head waste of *Metapenaeus dobsoni* were 8.06±0.05%, and 10.07±0.11% respectively. The results of the present study were agreement with the report by Gunasekaran et al. (2015). The proximate analyses exhibited a high level of protein in the shrimp shell protein powder which suggested the scope of utilization of this protein as a functional food component in the human diet. The initial pH of the shrimp shell, SSPS, and SSPP was found to be in a higher range from 7.23 to 7.80. Similar observations were also reported by Sachindra et al. (2006).

Table 1. Proximate composition of shrimp shell, SSPS, and SSPP*

Parameters / Sample	Shrimp shell	Shrimp shell protein solution	Shrimp shell protein powder
Moisture (%)	78.18±2.97	86.43±0.53	11.06±0.21
Protein (%)	9.84±0.61	8.95±0.18	57.26±0.50
Ash (%)	4.83±0.10	1.55±0.19	9.79±0.04
Fat (%)	0.89±0.17	0.90±0.06	4.21±0.09

*Values are shown as Mean ± SD of duplicate determinations, results are presented on wet weight basis (%)

TVBN content of SSPS and SSPP was found to be within the acceptable limit. Shrimp shells contain 16.01±0.98 mg % TVBN and in SSPP it was observed as 15.33±0.10mg %. These values indicate freshness. The acceptability TVBN limit recommended for shrimp is 30-40 mg % (Mansur et al., 2018; Connell, 1995). Similar results have been reported in Indian white shrimp during chill storage (15.25 mg %) (Bindu et al., 2013). A study by Limam et al. (2008) on shrimp head protein and protein hydrolysate reported TVBN content as 2.89 mg % and 5.81 mg %. The TVBN of SSPS and SSPP were lower than the recommended consumable limit indicating the acceptable freshness of the raw materials. The recommended TMA content limit for fresh shrimp is 5-15 mg % (Sukkwai, 2017). The TMA content of SSPS, SSPP, and shrimp shell ranged from 5.53±0.10 to 7.31±0.49 mg % which indicate that the TMA content of SSPS, SSPP, and Shrimp Shell was also within the recommended limit.

In the raw shell peroxide value (PV) was not detected, were as the PV of SSPS was found to be 15.28 meq.O_2kg^{-1} and a slight increase after spray drying to 18.65 meq.O_2kg^{-1} for SSPP. The acceptable limit for PV in fishery products is 3 to 20 meq.O_2 kg^{-1} (Young, 1986). In this study, the PV of Shrimp shell, SSPS, and SSPP did not exceed the acceptable limit. The FFA content of SSPP was reported as higher about 15.89% of oleic acid compared to SSPS and shrimp shell. TBARS is a widely used index for determining the degree of lipid oxidation and secondary production of oxidation in fish and fishery products (Ibrahim, 2007). The presence of secondary oxidative substances affects the sensory quality of the products. The maximum TBA limit for fish products is < 5 mg malondialdehyde kg^{-1}

Table 2. Chemical quality of SSPS and SSPP*

Sample/ Parameter	TVB-N (mg%)	TMA-N (mg%)	PV (meq. O_2 kg^{-1})	FFA (% of oleic acid)	TBA (mg MDA kg^{-1})
Shrimp shell	16.01±0.98	7.31±0.49	Nil	11.35±1.07	0.24±0.00
SSPS	13.95±0.08	5.53±0.10	15.28±0.04	11.67±1.27	0.16±0.01
SSPP	15.33±0.10	6.92±1.0.10	18.65±0.38	15.89±1.07	0.98±0.02

*Values are shown as Mean ± SD of duplicate determinations.

(Ucak & Durmus., 2011). The TBA value of shrimp shell, SSPS, and SSPP are shown in Table 2. The low levels of TVB, TMA, and TBA indicate that the quality of shrimp shell used for the study was fresh. Similar observations were also reported by Heu et al., (2003) in shrimp by-products.

Foam properties are important parameters for functional protein foods. The foaming capacity is the measure of the volume that can be formed by whipping the protein. Foam stability is the measure of time required to lose the volume from the foam (Mauer, 2003). The functional properties of shrimp shell protein powder are shown in Table 3. The foaming properties were reported for different fish protein hydrolysate ranging from 22.33% to 70% was noticed (Parvathy et al., 2018). The water absorption capacity (WAC) and oil absorption capacity (OAC) is the index that shows the ability of the protein to absorb and retain water or oil, which influences the sensory properties of the food products. The OAC and WAC of SSPP are given in Table 3, which showed lower oil absorption properties compared to casein proteins reported as 1.4 ± 0.2g^{-1}. Similar to this finding, OAC of shrimp head was reported as 1.2 ± 0.3g^{-1} by Limam et al. (2008). The water abortion capacity of the protein is dependent upon the amino acid composition, polarity and hydrophobicity of the molecule. The SSPP had shown a water absorption capacity of 0.41±0.50 ml water g^{-1} protein (Table 3). Shrimp shell protein powder (SSPP) had observed a lower WAC compared to shrimp protein hydrolysate 1.21 ml water g^{-1} as reported by Jeyakumari et al. (2016). Higher moisture absorption indicate the hygroscopic nature of SSPP. The hygroscopicity of SSPP was found to be 31.82±0.39 g %. The hygroscopicity of SSPP is in good agreement with that reported for chicken meat protein hydrolysate 40.9 g % (Kurozawa et al., 2009). The flow properties of shrimp shell protein (SSPP) are given in Table 3. The Carr's index value and Hausner ratio of Shrimp shell protein powder was 28.23±0.35 and 1.39±0.01, respectively which falls under the category of poor flow properties according to Turchiuli et al. (2005).

Table 3. Functional properties of shrimp shell protein powder*

Foaming capacity (%)	71.55±0.07
Foaming stability (%)	50.3±0.14
OAC (ml $oilg^{-1}$)	1.15±0.20
WAC (ml water g^{-1})	0.41±0.50
Hygroscopicity (g %)	31.82±0.39
Bulk density (gml^{-1})	0.21±0.12
Tapped density (g ml^{-1})	0.29±0.30
Carr index	28.23±0.35
Hausner ratio	1.39±0.01

*Values are shown as Mean ± SD of duplicate determinations.

Color is an important quality attribute of food. Color measurement in food processing is used to optimize food ingredients, and to analyze the changes in colour during processing and storage. In most food products during the heat process, the colour is developed due to the Maillard reaction (Jeyakumari et al., 2016). Hunter color parameters of SSPP for *L**, *a**, and *b** values were 53.97±0.05, 16.06±0.10, and 30.37±0.19, respectively.

From the study, it can be observed that good quality protein can be recovered from the shell of *Metapenaeus dobsoni* by mechanical process followed by spray drying with acceptable biochemical qualities for food applications. During mechanical separation, harmful chemicals were not used in the protein recovery. Since, no harmful chemicals were used for the recovery, the protein powder developed through

this green extraction technique can have a wide range of application as a functional food ingredient for the development of value-added food products. The spray drying of protein solution will increase the storage stability and provides convenience for food applications. Results suggested that protein from shrimp shell could be considered an alternative source of protein in food products.

References

AOAC (2019) Official Methods of Analysis, 21th Edition, Association of Official Analytical Chemists International, Maryland, USA

Bindu, J., Ginson, J., Kamalakanth, C. K., Asha, K. K. and Srinivasa Gopal, T. K. (2013) Physico-chemical changes in high pressure treated Indian white prawn (Fenneropenaeus indicus) during chill storage. Innov. Food Sci. Emerg. Technol. 17: 37-42

Chinta, D. D., Graves, R. A., Pamujula, S., Praetorius, N., Bostanian, L. A. and Mandal, T. K. (2009) Spray-Dried Chitosan as a Direct Compression Tableting Excipient. Drug Dev. Ind. Pharm. 35(1): 43-48

Connell, J. J. (1995) Control of fish quality (4th ed.) London: Fishing News Books Limited

Conway, E. J. (1962) Microdiffusion Analysis and Volumetric Error (5th ed.). Parch Goskey and Sockwood, London

FAO (2022) The State of World Fisheries and Aquaculture 2020. Sustainability in action. In Fao.

Gunasekaran, J., Kannuchamy, N., Kannaiyan, S., Chakraborti, R. and Gudipati, V. (2015) Protein Hydrolysates from Shrimp (*Metapenaeus dobsoni*) Head Waste: Optimization of Extraction Conditions by Response Surface Methodology. 24(5): 429-442

Haque, M. A. (2014) Drying and Denaturation of Proteins in Spray Drying Process. In Handbook of Industrial Drying. 1001-1014

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

Ibrahim Sallam, K. (2007) Antimicrobial and antioxidant effects of sodium acetate, sodium lactate, and sodium citrate in refrigerated sliced salmon. Food Control. 18(5): 566-575

Ibrahim, H. M., Salama, M. F. and El-Banna, H. A. (1999) Shrimp's waste: Chemical composition,

nutritional value and utilization. Nahrung – Food. 43(6): 418-423

Jayasundera, M., Adhikari, B. P., Adhikari, R. and Aldred, P. (2010) The effect of food-grade low-molecular-weight surfactants and sodium caseinate on spray drying of sugar-rich foods. Food Biophys. 5(2): 128-137

Jeyakumari, A., Sivadas, M., Das, R., Bindu, J., Joshy, C. G. and Zynudheen, A. A. (2016) Optimisation and comparative study on the addition of shrimp protein hydrolysate and shrimp powder on physicochemical properties of extruded snack. Int. J. Food Sci. 51(7): 1578-1585

Khan, M., Rahman, M., Rahman, M. and Alam, A. N. (2014) Development of protein enriched shrimp croquette from shrimp industry wastes. J. Bangladesh Agric. Univ. 11(2): 331-340

Kurozawa, L. E., Park, K. J. and Hubinger, M. D. (2009) Effect of carrier agents on the physicochemical properties of a spray dried chicken meat protein hydrolysate. J. Food Eng. 94(3-4): 326-333

Larsen, R., Eilertsen, K. E. and Elvevoll, E. O. (2011) Health Benefits of Marine Foods and Ingredients. Biotechnol. Adv. 29(5): 508-518

Limam, Z., Sadok, S. and Abed, A. El. (2008) Enzymatic Hydrolysis of Shrimp Head Waste: Functional and Biochemical Properties. Food Biotechnol. 22(4): 352-362

Mansur, M. A., Haider, M. N., Hasan, M. M., Matoba, T. and Kimura, D. (2018) Proximate composition, quality and flavor components of shrimp (Penaeus monodon, Penaeus orientalis and Pandalus hypsinotus). Bangladesh journal of fisheries. 30: 263-269

Mauer, L. (2003) PROTEIN | Heat Treatment for Food Proteins. Encyclopedia of Food Sciences and Nutrition, 4868-4872

MPEDA. (2020) MPEDA Newsletter. Printed and Published by Mr. K.S. Srinivas IAS, Chairman on Behalf of The Marine Products Export Development Authority (Ministry of Commerce & Industry, Govt. of India) MPEDA House, Panampilly Avenue Kochi - 682 036

Murthy, L. N., Phadke, G. G., Mohan, C. O., Chandra, M. V., Annamalai, J., Visnuvinayagam, S., Unnikrishnan, P. and Ravishankar, C. N. (2017) Characterization of Spray-Dried Hydrolyzed Proteins from Pink Perch Meat Added with Maltodextrin and Gum Arabic. J. Aquat. Food Prod. Technol. 26(8): 913-928

Nargis, A., Ahmed, K. N., Ahmed, G. M., Hossain, M. A. and Rahman, M. (2006) Nutrional value and use of shrimp head waste as fish meal. Bangladesh J. Scientific and Industrial Research. 41(1-2): 63-66

Parvathy, U., Nizam, K. M., Zynudheen, A. A., Ninan, G., Panda, S. K. and Ravishankar, C. N. (2018) Characterization of Fish Protein Hydrolysate from Red Meat of Euthynnus affinis and its Application as an Antioxidant in Iced Sardine. J Sci Ind Res. 77: 111-119

Rios, J. M. L. D. G. and Wasielesky, G. S. W. (2017) Functional and antioxidant properties of protein

hydrolysates obtained from white shrimp (Litopenaeus vannamei). J. Food Sci. Technol.

Sachindra, N. M., Bhaskar, N., Siddegowda, G. S., Sathisha, A. D. and Suresh, P. V. (2006) Recovery of carotenoids from ensilaged shrimp waste. Bioresour. Technol. 98(8): 1642-1646

Sathe, S. K. and Salunkhe, D. K. (1981) Functional properties of the Great Northern Bean (Phaseolus vulgaris L.) proteins: emulsion, foaming, viscosity and gelation properties. J. Food Sci. 46: 71-74

Shahidi, F., Han, X. Q.and Synowiecki, J. (1995) Production and characteristics of protein hydrolysates from capelin (Mallotus villosus). Food Chem. 53: 285-293

Sukkwai, S. (2017) Production of Flavorant and Colorant form Pacific White Shrimp (Litopenaeus Vanamei) Head and Their Food Appicatios. Prince of Songkla University.

Turchiuli, C., Fuchs, M., Bohin, M., Cuvelier, M. E., Ordonnaud, C., Peyrat- Maillard, M. N. and Dumoulina, E. (2005) Oil Encapsulation By Spray Drying And Fluidized Bed Agglomeration. Innov. Food Sci. Emerg, Technol. 6: 29-35

Ucak, I., & Durmus, M. (n.d.). (2011) The effects of rosemary extract combination with vacuum packing on the quality changes of Atlantic mackerel fish burgers. International Journal of Food Science & Technology. 46(6): 1157-1163

Young FVN. (1986) The refining and hydrogenation of fish oil. Fish Oil. Fish Oil Bulletin, International Association of Fish Meal Manufacturers, Hertfordshire, UK: St. Alban's, 17: 17