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Development of Protein Powder and Noodles from Squilla-Improved Utilization of an Unconventional Fishery Resource

Viji P.[1]*, Jesmi Debbarma[1], Madhusudana Rao B.[1] and George Ninan[2]

[1] *Visakhapatnam Research Centre of ICAR-Central Institute of Fisheries Technology, Pandurangapuram, Andhra University P.O., Visakhapatnam, Andhra Pradesh - 530 003*

[2] *ICAR-Central Institute of Fisheries Technology, Willington Island, Kochi - 682 029*

Abstract

Squilla belongs to stomatopod crustaceans, frequently caught as a non targeted species during shrimp trawling operations. In India, *Squilla sp*. doesn't attract any commercial value and remain unutilized. In the present work, protein powder was prepared from squilla (SPP) by foam mat drying technique using guar gum as a foam stabilizer. The yield of SPP from fresh squilla was 13.4 %. The protein content of fresh squilla meat and dried squilla powder was 13.46 and 66 %, respectively. Solubility of SPP in water was 41 %, and its water binding capacity was 262.23 %. Also, suitability of squilla protein powder (2.5 and 5 %) as a flavoring and protein source in noodles was evaluated. The cooking time of noodles varied from 4.36 min for control noodle to 5.53 min in 5 % SPP added noodles. Water absorption index of control, 2.5 % SPP noodle and 5 % SPP noodle was 185.87 %, 241.96 % and 197.92 %, respectively. Cooking loss was more with 5 % SPP added noodles (4.64 %). L* value of noodles decreased with an increase in squilla protein powder. Cooked noodles with 2.5 % SPP showed higher sensory scores in terms of flavor. In brief, the study demonstrated a promising approach towards the improved utilization of squilla for developing value-added products.

Keywords: Squilla, protein powder, noodles, sensory evaluation

Introduction

Squilla is a stomatopod crustacean under the family squillidae. In India, Squilla or mantis shrimp is considered as an unconventional crustacean resource for human consumption but is frequently caught as a by-catch in shrimp trawlers. Squilla resources are seasonal and during the peak season, it accounts for 30-40 % of total catch in shrimp trawlers (Personal Communication). Since this resource has little commercial importance, unwanted catches of squilla are discarded in the sea to reduce the load on fishing vessel. A minor quantity of squilla catch is directed to by-products/animal feed industry where it is used for chitin/chitosan production or squilla meal production. Utilization of squilla as food is limited due to its high moisture content, yielding less meat after cooking and also because of the difficulty in separating its meat from the shell. However, squilla is recently gaining importance as an alternative to shrimp seafood in other countries. There are few reports on the development of value-added products such as fish fingers and crackers from *Squilla mantis* (AbouZeed, 2016). In India, studies on production of chitosan (Madhavan & Ramachandran, 1975; Zynudheen et al., 2009), protein (Mathew et al., 1982), pickle, mince-based products (Tanuja, 1996), and silage (Bijoy et al., 2016) from squilla have been reported. However, there is a research gap in the area of development of shelf stable value-added products from squilla. In the backdrop of depleting marine resources from Indian waters, developing commercially valuable food products from unconventional resources like squilla requires more attention.

Noodles are considered as a staple food commodity in many of the Asian countries (Gulia et al., 2014). India is the fourth largest instant noodles market, accounted for 5.4 billion servings in 2017, according to World Instant Noodles Association. Being a poor source of protein and other nutrients, significant research attention has been given to noodles over the years to improve the nutritional value of conven-

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*Email- pankyammaviji@gmail.com

tional noodles by fortifying it with different sources of nutrients. According to Gulia et al. (2014), fortification of instant noodles is mostly done by fortifying the base material (flour) with other protein rich flours, vitamins and mineral mixes. Fish protein has also been successfully used to enrich the nutritional value of instant noodles (Parvathy et al., 2017). Fish protein powders find a wide range of applications in the food industry as a functional value added ingredient, binder, dispersing and emulsifying agent, and for enrichment of food products (Shaviklo, 2015). Commonly, under exploited low value fishes and protein rich fishery waste (by-products) are utilized as raw material for edible fish protein powder. The present study was aimed to prepare dehydrated protein rich powder from squilla resource by foam mat drying technique. Foam mat drying is a drying technique practiced in food industry for drying high-moisture foods like fruit juice or vegetables. The process involves the formation of stable foam by adding a whipping agent into liquid or semi liquid foods and subsequent whipping. The foam facilitates rapid drying and retention of nutritional quality of heat sensitive food materials. Efficacy of squilla protein powder as a protein/seafood flavor source in noodles was also evaluated in the study. To the best of our knowledge, this is the first report on foam mat drying of squilla protein and development of squilla based noodles.

Materials and Methods

Fresh squilla (average weight 27.14 ± 1.63g) caught by shrimp trawlers were brought to the laboratory in chilled condition. After thorough washing, head and tail of squilla were removed and the shell on squilla was chopped into smaller pieces manually. Hot water extraction process was followed as an easy step to collect meat from squilla. For this, the dressed pieces were heated for 30 min in potable water (1:1 ratio) maintained at 60ºC with intermittent stirring. The muscle portion got extracted into the water, which was then filtered by cheese cloth to remove the chitinous matter, if any. The process was repeated twice to extract maximum possible meat from the shell. The filtrate was pooled and centrifuged at 5000 rpm for 15 min in a bucket centrifuge. The residue obtained after centrifugation was whipped to make stable foam with the addition of guar gum solution (0.5 % w/v) in 1:1 ratio. The concentration of guar gum was selected based on literature review. The whipped slurry was spread as a foam and dried at 50ºC to a moisture content of 15 %. The dried mass was powdered and stored at ambient temperature for further analysis. Physico-chemical properties of the protein powder such as proximate composition (AOAC, 2000), bulk density and tapped density (Jinapong et al., 2008), instrumental color parameters (color Flex EZ colorimeter), water solubility index (Falade & Okocha, 2012), water binding capacity and foaming properties (Sathe et al., 1981) were analysed.

Noodles were prepared following a standard composition (Table 1) by adding squilla protein powder at different concentrations (replacing Maida by 2.5 % (T1) and 5 % w/w (T2)). Noodles prepared without the addition of squilla protein powder was served as the control (C). Effects of squilla protein addition on proximate composition (AOAC, 2000), cooking time and cooking loss (AACC, 1995), water absorption index (AACC, 1995), instrumental color parameters were evaluated. For sensory analysis, the samples were cooked for their optimum cooking time and its color and appearance, odour, texture (stickiness/roughness/firmness) and flavor (odour, taste and starchy mouth feeling) were evaluated on a 9-point hedonic scale described by Amerine et al. (1956). Mean value of four a forementioned sensory parameter's score was considered as overall acceptability score. Statistical analysis of data was performed by SPSS software, version 16.0. Mean values of the parameters were considered significantly different when P value was <0.05.

Results and Discussion

In the present work, a simple technology (hot water extraction method) was employed to separate meat from squilla shell. The collected meat was dehydrated to enrich the protein content. The process

Table 1. Composition of noodles

Ingredients	Type of noodles		
	Control	T1 (2.5% SPP)	T2 (5% SPP)
Refined wheat flour (g)	80.0	77.5	75.0
Squilla protein powder	0.0	2.5	5.0
Corn flour (g)	5.0	5.0	5.0
Tapioca starch (g)	10.0	10.0	10.0
Salt (g)	3.0	3.0	3.0
Refined vegetable oil (ml)	2.0	2.0	2.0
Water (ml)	40.0	40.0	40.0

yielded 13.4 % protein powder from fresh whole squilla. Proximate composition of squilla meat and squilla protein powder is depicted in Figure 1. Moisture and protein content of fresh squilla meat was 82.94 and 13.24 %, respectively. The result shows that moisture content is comparatively higher. The result was similar to Mili et al. (2013), who reported 81-83 % moisture and 11-12.3% protein content in three squilla species caught from Tunisian waters. Keshk & Emara (2018) reported 79.5 % moisture in *S. mantis* from Egypt. Protein content of squilla protein powder was 66.7 % on a wet weight basis, which agrees with the food safety and standards authority (FSSAI) requirement of minimum protein content (60 %) in edible fish powder. The fat and ash content of protein powder were 4.9 and 2.24 %, respectively. The results indicate that the squilla protein powder is rich in nutritional composites. Mathew et al. (1982) prepared squilla protein using cold water extraction and precipitation technique. The authors reported protein content as high as 65.5% in the dried protein. They also compared the growth rate and protein efficiency ratio in albino rats fed with squilla protein diet to that of casein fed diet and found similar.

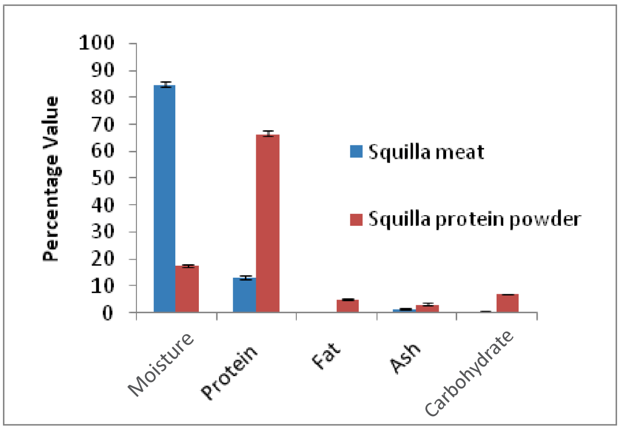

Fig. 1. Proximate composition of squilla meat and squilla protein powder

The physicochemical characteristics of squilla protein powder are presented in Table 2. Density of food powder is an important factor in deciding the packaging requirements. Bulk density depicts the mass of a solid that occupies a unit volume. The loose bulk density of a powder has a role in deciding the size of container and strength of the reconstituted food (Ding et al., 2020). A high bulk density is often desirable for reducing the packaging costs because more powder can be packed in a fixed volume container. Abdollahi & Undeland (2018) reported bulk densities varying from 0.48-0.60 g/ml for reference proteins including egg white protein, whey protein isolate and soy protein isolate powders. Bulk density of squilla protein powder prepared in the present study was similar to those reported for fish flours prepared from small indigenous fishes by Tiwari et al. (2016). Tapped density is the increased bulk density of a powder after it was tapped for several times in the measuring cylinder. Lightness (L*) and redness (a*) of the protein powder were 49.49±0.46 and 4.65±0.04, respectively. The values show that the powder color was more reddish. Color of the protein powders prepared from seafood depends mainly on the species and processing conditions. Higher redness of the SPP could possibly be explained by the presence of astaxanthin pigments in squilla. Solubility of SPP in water, an important factor deciding the functional properties was determined as 41.35± 0.75%. Solubility of a powder in water indicates its dispersion ability in liquid medium. Several factors such as surface properties of amino acids, confirmation and molecular weight of protein influence the solubility of protein in water (Timilsena et al., 2016). Solubility obtained for SPP in the present study is markedly higher than those reported for freeze dried saithe powder (Shavilok et al., 2012). There is a paucity of literature on the solubility of dried fish/ shrimp protein powder in water. In general, the hydrolysates of protein or protein isolates show higher solubility, depending on the pH of the water. It is important to note that in the present study, protein of squilla was not hydrolysed, but denatured by heat treatment, and in this perspective, the solubility expressed by dried protein powder can be considered high. This shows the hydrophilic property of the native complex protein molecule of squilla and can contribute to enhanced functional properties like emulsifying or foaming capacities. Higher water solubility of SPP owes to the hydrophilic property of squilla protein which needs to be researched in details. Water binding capacity indicates the rehydration ability of the powder, measured as the weight of water absorbed by the unit weight of powder. The WBC of SPP was 262.23±2.94 %, which points out the excellent rehydration ability of squilla protein powder. Foaming properties of protein is an essential requirement for its employment in food formulations, where aeration and overrun is involved (baked foods, ice cream mixes, whipped creams, beverages etc.). The major factors that decide the foaming capacity of a protein are; the source of protein, method of production, pH, concentration of protein, method and time of foam preparation etc. (Zayas, 1997). In the present work, though native protein of SPP had good water solubility, its foaming capacity was comparatively poor (36.29%). However, the stability of the foam was excellent (81.89%). It has been reported previously that a protein, which can make more stable foam may have poor foaming capacity (Wilde & Clark 1996).

Table 2. Physico-chemical attributes of squilla protein powder

Parameter	Value*
Bulk density (g/cm^3)	: 0.58±0.04
Tapped density (g/cm^3)	: 0.61±0.07
L*	: 49.49±0.46
a*	: 4.65±0.04
Solubility in water (%)	: 41.35±0.75
Water binding capacity (%)	: 262.23±2.94
Foaming capacity (%)	: 36.29±1.25
Foam stability (%)	: 81.89±2.86

*Values are mean± standard deviation
(n=3)

Noodles are trendy convenient food products and are a suitable commodity for enrichment for the reason that it is easy to prepare, economical in processing and have a longer shelf life. Analysis of proximate composition indicated a significant increase ($p<0.05$) in protein content (Table 3) of noodles prepared with the addition of squilla protein powder. A slight, but insignificant increase in fat and ash contents were observed with the incorporation of squilla protein powder. Desai et al. (2018a) reported an increased lipid, protein and ash content in fish powder enriched pasta. Effect of SPP on important characteristics of noodles such as cooking time, cooking loss, water absorption index, color values etc. was evaluated. Cooking properties of noodles varied due to addition of squilla protein powder (Table 4). The optimum cooking time for SPP-added noodles was slightly higher (5.1 min for 2.5 % SPP and 5.53 min for 5 % SPP noodles), compared to the control (4.36 min). Squilla protein powder might have delayed the starch gelatinization process, the major factor deciding the cooking time of noodles and hence, increased the cooking time. Cooking loss of noodles is considered as an indicator of overall cooking performance as it measures the amount of solids lost into cooking water. Addition of SPP significantly increased the cooking loss of noodles. Cooking loss is a result of starch gelatinization, formation of gluten network and associated changes (Desai et al., 2018b). Changes in structural integrity during cooking that result from weakening or disruption of protein-starch matrix are the possible cause of cooking losses in noodles. Changes in gluten network structure reduce its ability to retain soluble materials on its surface. Interaction between protein andstarch might have influenced the gelatinization process and gluten structure in SPP added noodles. Water soluble fractions of SPP also might have contributed to increase in cooking loss. Researchers suggest that maximum cooking loss allowed can be 10 % (Feillet & Dexter, 1996; Bharatkumar & Prabhasankar, 2018) and the products developed in the present study showed cooking losses of 3.58, 4.23 and 4.64 % for control, 2.5 % SPP and 5 % SPP added noodles, respectively. Water absorption index gives a measure of amount of water absorbed by noodles during cooking and plays a major role in determining the cooking properties. Water absorption index of noodles significantly ($p<0.05$) increased with increasing concentration of SPP. Increased water absorption index in 2.5 % SPP added noodles can be possibly explained by the higher water binding capacity of squilla protein. However, at 5% SPP addition, competition between starch and protein for water uptake might have

Table 3. Proximate composition of SPP incorporated noodles

Sample/parameter	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Carbohydrate (%)
Control	13.96^{b}±0.17	5.85^{a}±0.39	1.107^{a}±0.14	2.59^{a}±0.36	77.60^{b}±0.98
T1 (2.5 % SPP)	12.90^{a}±0.48	8.21^{b}±0.84	1.194^{a}±0.18	2.89^{a}±0.20	75.30^{ab}±1.35
T2 (5 % SPP)	13.58^{b}±0.64	10.23^{c}±0.73	1.232^{a}±0.21	3.63^{a}±0.35	73.70^{a}±1.83

*Values are mean ± standard deviation
(n=3)

Table 4. Cooking properties and color attributes of SPP incorporated noodles

Sample/ parameter	Cooking time (Min)	Cooking loss (%)	Water absorption index	L*	a*	b*
Control	4.36^{a}±0.05	3.58^{a}±0.11	185.87^{a}±5.8	80.47^{c}±1.58	1.96^{a}±0.27	14.77^{b}±0.77
T1	5.1^{b}±0.13	4.23^{b}±0.11	241.96^{b}±6.01	73.24^{b}±0.76	3.83^{b}±0.11	13.34^{a}±0.18
T2	5.53^{c}±0.09	4.64^{c}±0.07	197.92^{a}±7.15	67.85^{a}±1.97	5.02^{c}±0.32	13.01^{a}±0.33

Values are mean(n=3)± standard deviation. For L, a*and b*, n=6. Different superscripts in same column indicate that values are significantly different at $p<0.05$.

resulted in lower water uptake by starch for its gelatinization, leading to a reduction in the water absorption index. Similar finding is also reported by Khatkar & Kaur (2018) in soy protein fortified pasta. Also, they reported increased cooking time and cooking loss with the addition of protein source.

Hunter color parameters, L* (lightness), a* (redness) and b* (yellowness) varied significantly ($p<0.05$) among the noodles. As expected, control noodles had the highest lightness (80.47) but lowest redness value (1.96), whereas noodles having 5% SPP had the lowest lightness value (67.85). The color parameters of control noodles agreed with the requirements for a desirable noodle: bright and light yellowish as reported previously by Kim (1996). Carotenoid pigments in squilla meat and their oxidation during heating and drying have accounted for the increased redness, resulting in lower lightness value of SPP added noodles. Park & Baik (2004) have reported that the quality of proteins has a significant role in deciding the redness (a*) value of noodles. The sensory evaluation test indicated higher acceptability for SPP-added noodles compared to control. However, a higher concentration of SPP reduced the overall acceptability (Figure 2). The panellists observed shrimp's flavour in SPP-added noodles. Addition of SPP upto 5 % imparted a slight salty flavour to noodles; hence, it scored lower in terms of flavour.

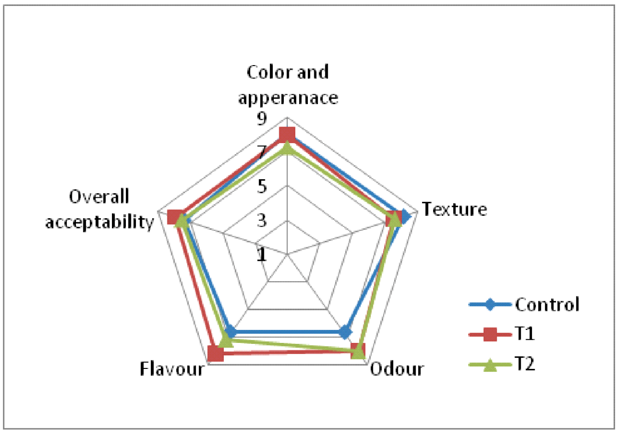

Fig. 2. Sensory evaluation scores of noodles incorporated with squilla protein powder

In summary, the study revealed that protein-rich powder can be prepared from squilla meat by employing hot water extraction followed by foam mat drying technique. Dehydrated squilla protein had 66.7% protein. The protein powder exhibited good solubility and water absorption characteristics, but its foaming properties were fair. Additionally, the protein powder could be successfully used to fortify instant noodles without significantly impairing its essential quality parameters. Hence, the results of the present study open up the opportunities for improved utilization of squilla resource, which is considered as low-value seafood.

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