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Functional Properties of Surimi Powder prepared from Croaker fish (*Otolihoides biauritus*)

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Abstract

Surimi industry forms an important sector in fish processing because of useful functional properties found in surimi which makes it a suitable raw material in the manufacture of restructured products. However, prolonged cold storage of surimi results in deterioration of its quality and increases storage costs. Therefore, drying surimi under controlled condition to make surimi powder which is stable at room temperature can be an alternative to traditional surimi and this leads to a new approach in surimi industry. In the present study, mechanical drying technique was evaluated for surimi powder prepared from croaker fish (*Otolihoides biauritus*). Functional properties of the prepared surimi powder were studied. This study revealed that the proximate composition of surimi and surimi powder showed significant difference ($p<0.05$) in protein, fat and ash contents. Functional quality parameters of surimi powder like solubility, water holding capacity, emulsifying capacity and foaming capacity values were 18.4%, 11 ml g^{-1}, 40% and 37.5% respectively. Instrumental colour parameters such as lightness, redness and yellowness values were significantly higher ($p<0.05$) in surimi powder than the surimi. Whiteness index observed was significantly higher ($p<0.05$) in surimi powder than the surimi. These results indicate that surimi powders can be used as a functional ingredient for the preparation of fish-based products as well as in food formulations, which of course need separate studies.

Keywords: Drying, Surimi powder, Functional properties, Myofibrillar protein

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Introduction

Surimi is a wet myofibrillar protein concentrate stabilized with the cryoprotectants including sugar, sorbitol and polyphosphate and finds good demand in international market. It is a source of raw material for several value-added fish products, especially analogue products. Modern-day fish industries are mostly dependent on the availability of fresh raw material for using it in the production of good quality end products. Surimi industries in this context require highly equipped freezing equipment and facilities of frozen storage for maintaining the quality of surimi. Lack of these facilities creates a scarcity of using frozen surimi as raw material for food systems. Converting surimi into protein concentrate powder can reduce the bulkiness of the product, making it more convenient for the industrial manufacturers to store large amounts of surimi powder in smaller space without the need for sophisticated frozen storage facilities, needed for frozen surimi. Surimi powder can even prove to be useful for producing friable products like crackers, apart from diverse gel based products (Santana et al., 2012).

Several earlier reports have been studied to convert surimi into a dried powder that is easy to handle and transport (Musa et al., 2005; Santana et al., 2012; Huda et al., 2001). To prepare surimi powder, the most commonly employed drying methods include freeze drying, spray drying, oven drying, solar drying, and mechanical drying. Drying process usually involves the removal of moisture from the product surface, followed by the transfer of internal moisture to the surface in order to prolong the final product shelf life. Freeze drying process, is an expensive method for removal of water from the matrix at a very low temperature via the sublimation of frozen water to vapour in a vacuum chamber. The spray drying removes water from products through

spray–air contact, converting fluid materials to a dried form. Oven drying constitutes a closed chamber for drying products by heating at a relatively high temperature (60ºC being the ambient) with three processes- heating, drying and baking. Solar drying is the cheapest and environmentally friendly drying method, the same principle of mechanical drying. Mechanical drying ventilates the products with heated air to evaporate the moisture (Santana et al., 2012).

However, utilizing surimi cold-stored for longer periods in the production of surimi powder concentrate have not yet been studied, where freshness of raw material is very vital. Functional properties such as solubility, gelation, water- holding capacity, emulsion, foaming and colour properties are important parameters for any surimi product either in wet or dried form. Cryoprotectants are usually added to protect the proteins (myosin and actomyosin) from denaturation during freezing as well as drying process. Hence, source and freshness of raw materials along with the amount of cryoprotectants (sugar or polyols) added to the surimi determines the final functionality and quality of any surimi product. However, for attracting a wider global consumer, the surimi powder must be functionally stable and nutritionally healthy. The mechanical drying of surimi has limitations as the process is carried out at high temperatures. The present study was undertaken to produce surimi powder from *Otolihoides biauritus* by mechanical drying method under controlled conditions and to study its functional properties for its final acceptance by the consumers.

Materials and Methods

Croaker (*Otolithoides biauritus*) a marine fish, was collected from Versova landing centre (North-West Mumbai coast) and processed for surimi preparation by conventional method (Gopakumar et al., 1992) at the fish processing laboratory of department of post-harvest technology at ICAR-Central Institute of Fisheries Education (CIFE), Mumbai, India. Briefly, the minced meat was washed in cold water (10°C), thrice with water to mince ratio of 3:1 and contact time of 10 min. The final wash water contained 0.2% sodium chloride to facilitate quick water removal. The wet surimi was mixed with cryoprotectants, sucrose (4%), sorbitol (4%) and polyphosphate (0.25%) by blending with the mince in a silent cutter for 1 min, further processing to surimi powder.

Frozen surimi was thawed under running water at 27±2ºC until the core temperature reached 5-7ºC. Surimi was dried using an accelerated mechanical dryer system (Yarrow and Co Ltd, Glasgow, Scotland) at a temperature of 55±2ºC and relative humidity 45% for 6 h until the moisture content attained below 10%. The dried sample was ground by grinder (Hobart AE 200, London, UK) and sieved using a 400 μm stainless steel screen mesh. This process was repeated alternatively until very less, or no dry residues remained. The resulting powder was vacuum-packed (ACE PAC, Vacupack, India) and stored at room temperature for further analysis.

The proximate composition of surimi powder and surimi were analysed according to AOAC (2005). Total nitrogen in the sample was estimated by the Kjeldahl steam distillation method (Pelican, Mumbai) and protein content was calculated by multiplying with a factor 6.25. Total lipid contents were determined by the Soxhlet method (Socs plus of Pelican, Chennai, India). Ash content was estimated by charring the sample in a muffle furnace (Expo, Hi-Tech; i-therm, AI-7941) for 6 h at 600±5ºC (AOAC, 2005). The final moisture content of both surimi powder and surimi were determined by drying the samples in hot air oven (Technico Laboratory Products Pvt. Ltd., Chennai) for 16-18 h at 100±5ºC (AOAC, 2005). The carbohydrate content of each sample was calculated by difference. Each parameter was analysed in three replicates and the mean values expressed as 100 g^{-1} of sample.

One gram of surimi powder was added to 40 mL of distilled water and 3% salt (NaCl) solution separately for measuring solubility. A homogeniser mixer (Polytrone PT-MR 2100, Kinematica AG, Switzerland) was used for 2 min (giving rest to the samples at 20-sec interval) to homogenise the samples. The homogenates were centrifuged (Eltek RC 4100F) at 6280 x g at 4ºC for 5 min and the supernatants was collected for protein estimation by Biuret method. The solubility of protein was calculated based on 100% solubility of the protein (Venugopal et al., 1996).

One gram of surimi powder was added to 40 mL distilled water separately in a 50-mL centrifuge tube and homogenised using a homogeniser mixer (Polytrone PT-MR 2100, Kinematica AG, Switzerland) for 5 min. Tubes were centrifuged in a refrigerated centrifuge (4ºC) at 7500 x g for 5 min (Eltek RC 4100F). The volume of supernatants was

measured into a 100 mL standard measuring cylinder. The volume of supernatant was subtracted from the original 40 mL. The results were estimated in terms of mL of water held by 1 g of protein (Mille & Groninger, 1976).

About 1 g of surimi powder was added to 25 mL of distilled water and 25 mL of vegetable oil (purchased from the local supermarket) separately. The mixture was blended for 1 min using a homogenizer (Polytrone PT-MR 2100, Kinematica AG, Switzerland) and transferred to two 50-mL calibrated centrifuge tube. The tubes were centrifuged at 7500 x g for 5 min at 4°C (Eltek RC 4100F). The emulsification capacity of the sample was estimated by dividing the emulsion volume after centrifugation by the original emulsion volume and then multiplying with 100 (Miller & Groninger, 1976).

Surimi powder (1 g) was added to 100 mL of distilled water in a homogenizer (Polytrone PT-MR 2100, Kinematica AG, Switzerland) and blended for 1 min at 10000 rpm speed separately. Volumes of the mixtures were measured carefully (without much disturbing the foam) into a 1000 mL^{-1} standard measuring cylinder. The foams were calculated for the sample as the volume of the mixture after blending compared to the original volume (Miller & Groninger, 1976).

The colour of surimi and surimi powder was measured by using a colorimeter (Labscan XE, Hunter colourlab) and colour values were measured using Easy Match QC, the software inbuilt in the colorimeter. The colour reading includes lightness L*(L*=0[black] and L*=100[white]), redness a*(-a*=greenness and +a*=redness) and yellowness b*(-b*=blueness and +b*=yellowness). Standard black and white colour plates were used to standardize the instrument.

The results were statistically analyzed using statistical package for the social science software (SPSS VERSION 16.0, Chicago IL. USA). Analysis of variance (ANOVA) was carried out, and the significant difference among the treatments were determined by Duncans Multiple Range Test (DMRT). The level of significance was set up at $p \leq 0.05$.

Results and Discussion

Table 1 represents the proximate composition of surimi and surimi powder prepared from *Otolithoides biauritus*. The moisture content in the surimi sample was 73.68%, and that of surimi powder was 8.64%. The reduction in the moisture content of surimi powder was due to the oblivious reason of drying process. The similar results were reported by Huda et al. (2000b) for surimi powder from lizardfish (*Saurida tumbil*) by oven drying method and Musa et al. (2002) for surimi powder from threadfin bream (*Nemipterus japonicus*) by solar drying method.

Table 1. Proximate composition of surimi and surimi powder

Parameters	Surimi	Surimi powder
Moisture (%)	73.68±0.45[a]	8.64±0.31[b]
Protein (%)	19.25±0.41[a]	69.41±0.44[b]
Fat (%)	0.16±0.09[a]	1.61±0.14[b]
Ash (%)	1.44±0.05[a]	5.80±0.23[b]
Carbohydrate (%)	5.47±0.25[a]	14.64±0.72[a]

Data expressed as the mean± SD (n=3), the mean value in the same row with different superscripts are significantly different ($p<0.05$).

Protein solubility is the primary functional property usually determined during the development and testing of new protein ingredients. Kinsella et al. (1976) have suggested that solubility of proteins is the most important factor and excellent index for their functionality. Protein solubility is a physico-chemical property that influences other functional properties (Vojdani, 1996) and generally influenced by its amino acid composition sequence, molecular weight, conformation and content of polar and nonpolar groups. Hydrophobic interactions promote protein-protein interactions whereas ionic interactions promote protein-water interactions that affect the solubility ranges. Ionic residues on the surface of proteins introduce electrostatic repulsion between protein molecules and repulsion between hydration shells around ionic groups, both major contributors to increased solubility of proteins. The solubility and water holding capacity of surimi powder is shown in Table 2. The solubility of protein from surimi powder was observed to be 18.4% in mechanical drying sample. However, the solubility values observed by Huda et al. (2001) and Huda et al. (2000 b) in dried surimi powders prepared from fish species like threadfin bream, purple spotted bigeye and lizard fish was around 8-11 % by freeze-drying methods and 28-30% in oven drying methods respectively. Differences in solubility can also be due to species used for surimi powder preparation.

Water holding capacity (WHC) is one of the pivotal properties in maintaining quality of any meat or meat-based products that directly signifies its economic viability and governs the meat quality changes. Water holding capacity of the surimi powder was 11 mL g^{-1} protein powder. Water holding capacity depends on the method used for drying (Musa et al., 2005), apart from type of fish species (Huda et al., 2001), amount of cryoprotectants (Huda et al., 2000b; Niki et al., 1992). The WHC values in surimi powder are inconsistent with the observations recorded by Huda et al. (2000b), where they reported a decrease in the water holding capacity due to protein denaturation as a result of drying at higher temperatures.

The emulsion capacity and foaming capacity of surimi powder is shown in Table 2. Emulsion capacity of surimi powder was found to be 40%. Hydrophilic and hydrophobic residues of proteins act as an emulsifier if there is a balance between these residues. Musa et al. (2002) found the emulsion capacity of 50% in solar dried surimi whereas the present study results indicated a less emulsion capacity (40%) in the surimi powder.

Foams can be defined as a mixture of gas in liquid (G/L) or liquid in gas (L/G) materials (Foegeding & Davis, 2011). The foaming property of the protein is influenced by the strength of the protein in trapping gases (Belitz et al., 2009). The foaming capacity of surimi powder was found to be 37.5%. Huda et al. (2001) observed 34.6% foaming capacity for freeze-dried threadfin bream surimi powder. However poorer functional properties were observed for oven dried samples when compared to spray dried and freeze dried samples (Shaviklo, 2015). The foaming capacity of surimi powder may be associated with the exposure of the SH group after heating (Gharbi et al., 2017) and alterations in protein conformation due to exposure to higher temperature.

Table 2. Functional properties of surimi powder

Parameter	Surimi powder
Solubility (%)	18.4±0.48
Water holding capacity (ml g^{-1})	11.0±0.10
Emulsifying capacity (%)	40.0±0.05
Foaming capacity (%)	37.5±0.28

Data expressed as mean ± SD (n=3)

Lightness (L^*), redness (a^*) and yellowness (b^*) values of surimi and surimi powder sample are shown in Table 3. There was a significant difference ($p<0.05$) in the colour characteristics among the samples studied. Surimi powder showed the greatest lightness value (72.96) than the surimi sample (53.42). This might be due to the higher surface area of surimi powder, which will result in higher whiteness. Instrumental a^* value was observed higher in the surimi powder than surimi. Increase in redness of surimi powder sample may be due to maillard reaction between sugars and proteins, as there was a higher concentration of protein in surimi powder there may be higher chances for the maillard reaction, higher temperatures will also favour the maillard reaction (Huda et al., 2000a). The yellowness value of surimi powder was greater (17.56) than the surimi sample (4.04). The high 'b' values indicate the surimi powders were yellowish to light brown in colour. These results of surimi powder are comparable with the results obtained by Musa et al. (2002). It can be concluded that factors such as fish species, drying methods and amounts of added cryoprotectants can influence the colour characteristics of surimi powder (Huda et al., 2001).

Table 3. Instrumental colour of surimi and surimi powder

Parameters	Surimi	Surimi powder
L^*	53.42±1.99^a	72.96±0.33^b
a^*	-2.26±0.15^a	-0.14±0.08^b
b^*	4.04±0.73^a	17.56±0.45^b
Whiteness	54.15±1.44^a	67.62±0.34^b

Data expressed as mean± SD (n=3), the mean value in the same row with different superscripts are significantly different ($p<0.05$).

The results of this study indicated that surimi powder produced from croaker fish showed functional attributes and nutritional composition with fish protein powders that can pave its utilization as an effective functional additive in several proteins-based food formulations. Further, color attributes of the surimi powder were found to be enhanced, making it a consumer appealing protein ingredient. Hence it can be concluded that conversion of raw surimi into a powder substitute can be an alternative for its convenient incorporation as protein ingredient in terms of facilities for its frozen storage, highly equipped machineries, distribution costs and ease of transportation, handling and long-term storage.

However, further research is needed to explore the suitability of surimi-based protein powders in food systems.

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