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Physico-chemical Properties and Proximate Composition of Surimi Powder from Tilapia (*Oreochromis mossambicus*)

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Abstract—*The term 'surimi' refers to concentrated myofibrillar protein extracted from fish flesh by washing minced meat that has been separated from bones, skin, and guts. During preparation of surimi, washing with cold water was done to remove fat and other water-soluble contents, thus insoluble myofibrillar protein is isolated. After being mixed with a cryoprotectant, this protein is called surimi. Surimi powder is prepared from frozen surimi blocks by adopting different drying technologies in order to prolong the shelf life and does not require frozen storage. Surimi powder can be turned into wet surimi by rehydrating it with four times its weight of water to make it similar to that of a frozen surimi block. Tilapia (Oreochromis mossambicus) with average total length and round weight 23.5±1.08 cm and 248.3±3.42 gm respectively were used to prepare dry surimi powder. Surimi was prepared by adding 4% sucrose, 4% sorbitol and 0.3% sodium tripolyphosphate. The final proximate composition for surimi powder obtained was 10.55±0.08%, 65.32±0.66%, 1.15±0.02%, 2.42±0.04% and 20.56±0.26% for moisture, protein, lipid, ash and carbohydrate respectively. The quality parameters such as total volatile base nitrogen (TVB-N), peroxide value (PV), free fatty acid (FFA) and thio-barbituric acid reactive substances (TBARS) were all found to be well within the recommended level of acceptability, whereas, the pH value determined (5.06±0.28) was lower than that of surimi suggesting a good quality of the product. The results of proximate composition and quality indices suggest that surimi powder can be prepared from tilapia with ease of handling, low distribution cost, minimum storage space, usefulness in dry mixtures to produce homogenous blends and easier protein standardization.*

1. INTRODUCTION

The term 'surimi', comes from the Japanese words 'suru' meaning 'to process' and 'mash/mi' meaning 'meat', refers to concentrated myofibrillar protein extracted from fish flesh by washing minced meat that has been separated from bones, skin and guts [1]. Surimi itself is a raw material currently used to produce many seafood products. Surimi also is utilized commercially to imitate high-value marine products, such as crab meat, scallops, and shrimp. Surimi powder that maintains the functional properties of protein also is a potentially useful raw material for making seafood products including gel-based products and friable food products such as crackers. The surimi industry initially grew successfully based on Alaska Pollock or walleye pollock (*Theragra chalcogramma*), the fish traditionally used for surimi preparation. Since the late 1980's, limited supply of Alaska pollock due to overfishing and huge increase in demand for surimi brought about the need for exploitation of species other than Alaska pollock. Technology now makes it possible to use various species, even high lipid pelagic fishes, for the production of both surimi and surimi-based products. Freshwater fish are excellent sources of well-balanced essential amino acid containing high quality digestible protein [2]. Some investigations have been done on the quality of the mince of freshwater fish like silver carp, tilapia and Thai pangas for the manufacture of surimi [3], [4]. During preparation of surimi, washing with cold water was done to remove fat and other water-soluble contents and insoluble myofibrillar protein is isolated. After being mixed with a cryoprotectant, this protein is called surimi [5]. Surimi generally comes in a block form and is stored frozen. Recent research indicates that surimi could be converted to a dried form, surimi powder, which can be kept without frozen storage. Surimi powder can be prepared from frozen surimi blocks by adopting different drying technologies in order to prolong the shelf life of a food product. Researchers in Mexico [6], Japan [7], and Norway [8] converted surimi materials into powder or dried proteins. The powdered surimi offers many advantages in commerce, such as ease of handling, lower distribution costs, more convenient storage and usefulness in dry mixes application [9]. Surimi powder can be turned into wet surimi by rehydrating it with four times its weight of water, so that wet rehydrated surimi powder would have water content similar to that of a frozen surimi block [1]. Dry mixing of surimi powder could help industries to modify the formulation of surimi-derived products, resulting in more homogenous blends and easier protein standardization. Therefore, the objective of the study is to produce dry surimi powder from tilapia (*Oreochromis mossambicus*) and assess the proximate composition and quality indices.

2. METHODOLOGY

2.1 Sample collection

Live tilapia (*Oreochromis mossambicus*) was purchased from the local fish market by simple random sampling and were transferred to the laboratory in iced condition, decapitated and filleted by hand. Total length and weight of the fish were measured. Yield of picked meat was calculated based on the whole fish and dressed fish weight respectively.

2.2 Proximate composition

Moisture of the experimental samples was measured by Moisture Balance (Precisa, Dietikon, Switzerland). Total nitrogen was estimated by Kjeldahl method [10]. Crude protein value was calculated by multiplying the total nitrogen value by a factor of 6.25. Estimation of total lipid was done by the method described by Bligh and Dyer [11]. The ash content was measured by the method of AOAC [10]. All the results were expressed on wet weight basis.

2.3 Quality parameters

Total TVB-N (Total Volatile Basic Nitrogen), FFA (Free Fatty Acid) and TBA (Thio-barbituric Acid) content were estimated by the method recommended by Nambudiri [12]. The PV of the lipid was determined iodometrically from the lipid extract according to Jacobs [13].

2.4 Preparation of washed mince

Surimi production was carried out through a protocol, with a series of steps, in which washing process is very important. Preparation of washed mince was done according to the method of Rawdkuen et al. [14]. The fish mince (i.e., the picked meat) was washed with cold water (4^0C) using a mince/washing medium ratio of 1:3 (w/v) to remove sarcoplasmic proteins, blood, pigment, fat and other low molecular weight components. The mixture was continuously stirred for 10 min in a cold room (4^0C). The washed mince was then filtered through four layers of cheese-cloth and subsequently dewatered by using a hydraulic pressing machine. Washing was performed three times. The third washing step was carried out using 0.5% NaCl solution with mince to NaCl solution ratio of 1:3 (w/v). Finally, the meat was subjected to processing and the final moisture content of the product was maintained about 79% level.

2.5 Production of surimi

After final dewatering, the washed mince was added with 4% sucrose, 4% sorbitol and 0.3% sodium tripolyphosphate, mixed well and frozen as blocks using a blast freezer. The frozen samples referred to as 'surimi' were kept under frozen storage at -18^0C till processing.

2.6 Production of surimi powder

Surimi samples were oven dried to prepare dry surimi powder as described by Huda et al. [15] with modifications. Surimi blocks were taken out from the frozen storage and thawed to room temperature for 4 hours. Then raw surimi blocks were cut into pieces and placed in 50x30 cm aluminum trays. Finally, the aluminum trays with surimi samples were kept at 60 ± 5^0C temperature in a conventional hot-air oven for overnight until the moisture content was below 15%. The dried surimi was then milled to powder with a blender and sieved through a 30mm screen mesh. The surimi powders were then stored in airtight plastic packs at 4^0C for further processing.

2.7 Statistical Analysis

All of the data were checked for normal distributions with normality plots prior to two-way analysis of variance (ANOVA), to determine significant differences among means at $\alpha = 0.05$ level, using statistical tools of R software.

3. RESULTS AND DISCUSSION

The average total length and round weight of the experimental fishes were 23.5±1.08 cm and 248.3±3.42 gm respectively which is higher than that reported by Chakraborty et al. [16] wherein average total length and round weight was 19.8cm and 180.6g respectively. This could be due to the variations in season of catch and maturity of the fish species. The yield percentages during different steps of surimi and surimi powder processing are given in Table 1.

The adopted washing procedure for surimi preparation showed a varying percentage of yields during each washing step, which are shown in Table 2. One of the most critical steps in surimi manufacturing is the washing of minced fish flesh. Water leaching facilitates the concentration of myofibrillar protein by removal of water soluble proteins, blood, fat and other nitrogenous compounds from minced fish meats [17]. This process can improve the functionality and sensory characteristic of fish meat by eliminating the problems associated with colour, taste, odour etc. [14]. By reducing the amount of water soluble proteins and undesirable matters from minced meat, this process helps to concentrate the myofibrillar proteins and thereby, improves the functional properties of surimi [18]. The washing process involves mixing minced meat with cold water (5°C) and removing water by screening and dehydrators or centrifuging to about 5-10% solids [19]. Finally, the meat was subjected to pressing and the final moisture content of the product was maintained at 79% level. According to Shaviklo [20] a level of 82-85% moisture in washed mince is similar to that in the fish fillets. Park and Kim [18] reported that the number of washing cycles and the volume of water vary with fish species, freshness of fish, type of washing unit and the desired quality of the surimi. However, due to rising utility costs, limited water sources and pollution problems, minimization of water usage for leaching and reduction of wastewater disposal have recently become a major consideration for surimi manufacturers [21]. Protein recovery of 67.9% from tilapia mince using 3 cycles with a 1:3 (w/w) ratio of mince to water was reported by Rawdkuen et al. [14]. However, in the present study a final yield of 61.93±1.06% was observed after third washing cycle of tilapia mince (Table 1 and 2).

Table 1: Yields (%) during production steps of surimi and surimi powder

Processing steps	%
Whole fish	100.00±0.00
Fillets to whole fish	64.12±1.12
Head to whole fish	14.45±0.62
Viscera, bones, scales to whole fish	21.42±0.47
Minced flesh to whole fish	49.99±0.70
Minced flesh to fillets	77.95±2.35
Washed mince to whole fish	30.33±0.79
Washed mince to fillet	47.05±1.27
Washed mince to minced flesh	61.93±1.06
Surimi to whole fish	31.83±1.47
Surimi to fillet	49.64±2.20
Surimi to minced flesh	62.22±1.51
Dry Surimi to Surimi powder	22.22±0.86

**Results are mean of three determinations (n=3) with s.d*

Table 2: Yield of washed mince after each washing cycle

Washing steps	Yield (%)
Minced flesh	100±0.00
Washed mince to minced flesh 1st wash	73.33±2.14
Washed mince to minced flesh 2nd wash	71.11±1.88
Washed mince to minced flesh 3rd wash	61.93±1.06

**Results are mean of three determinations (n=3) with s.d*

Before processing, proximate and biochemical parameters (quality characteristics) of the raw whole fishes were analysed to assess the quality of the meat and tabulated in Table 3. The values for moisture, protein, lipid and ash were 80.3±0.20%, 17.31±0.22%, 1.31±0.02% and 1.07±0.01% respectively which is fairly consistent with the findings of Chakraborty et al., [16] for tilapia. The quality parameters like TVB-N (2.36±0.14 mg/100gm), PV (0.32±0.01 meq active O_2/kg), FFA (0.42±0.01g/100gm) and TBA (0.14±0.01 mg malonaldehyde/kg) were all within the limit of acceptability suggesting a good quality of raw material. According to Connell, [22] the acceptable limit of TVB-N is 20 mg/100gm, while 35 mg/100gm was reported by Ghaly, [23] as the permissible limit of TVB-N. Freshly caught tilapia, silver carp and *L. gonius* are reported to contain TVB-N of about 2.42mg% [16], 2.55mg% [4] and 11.37 mg% [24] respectively**.** The peroxide value (PV) is regarded as a useful and reliable method to estimate the extent of auto-oxidation in the early stage [16]. The PV upto 30 miliequivalent of O_2/kg of fat is considered as perfect without any objectionable off-taste or off-odour [25]. TBA value is used as an index of secondary oxidation of lipids. Connell, [22] suggested the safe level of TBA to be 1-2 mg of malonaldehyde/kg of sample suggesting that the surimi produced in the present study has less secondary oxidation level. Bouriga et al. [26] showed a value of 1.23% of oleic acid as FFA content in fresh Nile tilapia which in the surimi of the present study is lower. After final dewatering, the washed mince was added with 4% sucrose, 4% sorbitol and 0.3% sodium tripolyphosphate, mixed well, frozen in blocks and kept under frozen storage at -18^0C till processing. Sucrose addition is known to stabilize proteins against heat denaturation [27] and protects fish myofibrillar protein during freezing [28].

Table 3: Proximate composition and quality characteristics of whole fish

Proximate composition	
Moisture (%)	80.3±0.20
Protein (%)	17.31±0.22
Lipid (%)	1.31±0.02
Ash (%)	1.07±0.01
Biochemical parameters	
TVBN (mg/100g)	2.36±0.14
PV (meq active oxygen/kg)	0.32±0.01
FFA (g/100g)	0.42±0.01
TBA (mg malonaldehyde/kg)	0.14±0.01
pH	6.60±0.12

**Results are mean of three determinations (n=3) with s.d*

Proximate composition and biochemical parameters were analyzed during different stages of surimi processing and surimi powder preparation are depicted in Table 4. Protein content of 18.00±0.20 % and 16.49±0.18% was obtained for washed mince and surimi respectively. The protein values are fairly consistent with the reports of Hossain et al. [3], who showed that fresh silver carp and pangus surimi contain 16.12% and 16.8% crude protein respectively. The moisture content, obtained in the present study was 80.33±0.22% and 74.34±0.36% (Table 4) for washed mince and surimi respectively. According to Park, [29] moisture content of commercial surimi varies from 72 to 77%. Chowdhury et al. [4] found that silver carp surimi contains 78.06% moisture which fairly justifies the present findings. A gradual decrease in lipid content was observed at the different stages of surimi processing with the highest 1.25±0.01% (Table 4) encountered in minced meat. Washing step resulted in reduction of lipid content to 0.66±0.03% and further lowering to 0.53±0.01% was observed for surimi (Table 4). Low-fat content is very important to get good quality gel emulsion and analogue products [16]. Repeated washing process reduces the final lipid content of surimi from the fresh meat. Chowdhury et al. [4] reported final lipid content of silver carp surimi is 0.82% with a reduction of about 72.02% from the initial value. The ash content of surimi was determined to be 0.74±0.02%(Table 4) which is higher than the values as reported by Hossain et al. [3] in silver carp (0.56%) and pungas (0.43%) surimi. According to Chowdhury et al. [4] the amount of total ash content in silver carp surimi was around 0.82% which is in fair agreement with the results of present study. The carbohydrate content of 8% reported in Table 4 is entirely contributed by the sucrose and sorbitol added to minced meat as cryoprotectant.

Bio-chemical parameters such as TVB-N, PV, FFA and TBARS were determined to analyse the quality characteristics of both the washed mince and tilapia surimi. The values of all parameters (Table 4) were found to be well within the limit of acceptability. For washed mince TVB-N, PV, FFA and TBARS values were 1.92±0.02 mg/100g, 0.30±0.01 meq active oxygen/kg, 0.68±0.01 g/100g and 0.23±0.01 mg malonaldehyde/kg respectively. In case of surimi the values for the same parameters were 3.24±0.05 mg/100g, 0.28±0.01 meq active oxygen/kg, 0.62±0.02 g/100g and 0.18±0.01 mg malonaldehyde/kg respectively. A study made by Chakraborty et al. [16] reported similar findings for tilapia surimi where the TVB-N, TBA, PV and pH values are 3.27 mg%, 1.16 mg of malonaldehyde/kg of sample, 14.54 milliequivalent of O_2/kg of fat and 6.81 respectively. Similarly, the TVB-N, PV and FFA content of fresh silver carp surimi was reported to be 4.52 mg%, 83.71% of total nitrogen, 9.0 milliequivalent of O_2/kg of fat and 2.26% of oleic acid respectively [4]. A pH value, 6.8 to 6.9 is considered to be optimum for good quality surimi [16]. In the present study, a pH value of 6.90±0.44 was determined for fresh tilapia surimi suggesting that the value is within the limit criteria.

Table 4: Proximate composition and quality characteristics of fish mince at different stages of surimi and surimi powder processing

Parameters	Mince meat	Washed mince	Surimi	Surimi powder
Proximate composition				
Moisture (%)	80.6± 0.18	80.33± 0.22	74.34± 0.36	10.55± 0.08
Protein (%)	17.26± 0.07	18.00± 0.20	16.49± 0.18	65.32± 0.66
Lipid (%)	1.25± 0.01	0.66± 0.03	0.53± 0.01	1.15± 0.02
Ash (%)	1.08± 0.01	1.085± 0.01	0.74± 0.02	2.42± 0.04
Carbohydrate (%)	0± 0.00	0± 0.00	8.00± 0.00	20.56± 0.26
Biochemical parameter				
TVBN (mg/100g)	2.42± 0.04	1.92± 0.02	3.24± 0.05	7.50± 0.48
PV (meq active oxygen/kg)	0.28± 0.02	0.30± 0.01	0.28± 0.01	1.18± 0.01
FFA (g/100g)	0.42± 0.01	0.68± 0.01	0.62± 0.02	1.14± 0.02
TBARS (mg malonaldehyde/kg)	0.14± 0.01	0.23± 0.01	0.18± 0.01	0.38± 0.02
pH	6.81± 0.08	6.97± 0.04	6.90± 0.44	5.06± 0.28

**Results are mean of three determinations (n=3) with s.d.*

Proximate composition of the surimi powder varies upon different fish and different incorporation rates of sugars (sucrose, sorbitol, trehalose etc.), which were added with surimi to protect its functional properties against freezing and drying. As protein is the main constituent, a surimi powder having more than 65% protein can be classified as a fish protein concentrate (FPC) as per FAO [30]. The final proximate composition for surimi powder obtained was 10.55±0.08%, 65.32±0.66%, 1.15±0.02%, 2.42±0.04% and 20.56±0.26% for moisture, protein, lipid, ash and carbohydrate respectively (Table 4). According to Huda et al. [31] surimi powder from lizard fish was reported to contain 73.4% protein, 5.2% moisture, 1.9% fat, 1.9% ash and 17.5% carbohydrate. The protein contents of tilapia and trout surimi powder were 57.8% and 64.8% respectively [31]. A study conducted by Ramirez et al.[32] postulated that freeze-dried tilapia surimi powder contains 62% protein, 4.6% moisture, 2.9% fat, 1.6% ash and 8% carbohydrate when 8% sucrose was used as cryoprotectant during surimi preparation which corroborates with the results of the present investigation. The high content of carbohydrate in surimi powder was observed due to the addition of cryoprotectants during surimi preparation. Huda et al. [31] found that incorporation of 8% cryoprotectant during tilapia and trout surimi preparation resulted in a final carbohydrate content of 33.5% and 30.7% respectively, which is found to be higher than the carbohydrate content (20.56±0.26%) observed in the present study. The quality parameters such as TVB-N, PV, FFA and TBARS (Table 4) were all found to be well within the recommended level of acceptability as indicated earlier, whereas, the pH value determined (5.06±0.28) was lower than that of surimi suggesting a good quality of the product.

4. CONCLUSION

Production of surimi powder is an important technological advancement considering the ease of storing under normal refrigeration condition. Dry surimi powder is the way to decrease huge cost of freezing and frozen storage and can be transferred to the wet surimi by rehydrating it with four times its weight of water, with moisture content like the initial surimi block. Tilapia (*Oreochromis mossambicus*) was chosen for manufacturing surimi powder due to their easy availability and low price. The results of proximate composition and quality indices suggest that surimi powder can be prepared from tilapia with ease of handling, low distribution cost and space, minimum storage space required, usefulness in dry mixtures to produce homogenous blends and easier protein standardization.

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