Effect of Drying Temperature on the Quality of Dry Surimi Powder from *Pangasius*

ABSTRACT

Demands for fish protein including dried fish protein to develop functional food are gradually growing in the world. Surimi, the concentrated myofibrillar protein extracted from fish flesh by washing minced meat, separated from bones, skin, and guts with added cryoprotectants such as sugar or alcohol (most commonly used cryoprotectant in the surimi industry is 1:1 mixture of sucrose and sorbitol at a concentration of 8%), finally stored in frozen condition in block form, is used as a raw material for preparation of number of value-added products. The dried form of surimi can be prepared from frozen surimi blocks by adopting different drying technologies and it offers many advantages such as ease of handling, lower distribution costs and more convenient storage. The present work is aimed to study the effect of drying temperature on the quality of dry surimi powder, prepared from *Pangasius* meat. A significantly higher ($p<0.05$) value of ash (1.83±0.47%) was recorded in surimi powder dried at 60^{O}C than at 50^{O} and 70^{O}C. The moisture content significantly ($p<0.05$) reduced at 60^{O} (9.05±0.22%) and 70^{O}C (9.55±0.51%) as compared to 50^{O}C. The quality parameters such as TVB-N, PV, pH and TPC were all found to be well within the recommended level of acceptability except for the surimi powder dried at 50^{O}C, wherein the TVBN (36.24±1.26 mg/100g) crossed the limit of acceptability. Drying temperature was found to affect the colour of the surimi powder with the optimum acceptable colour score achieved at 60^{O}C (6.38±0.52). At higher temperature of 70^{O}C darkening was observed with consequent decrease in the colour scores (5.75±0.46). Therefore, the optimal temperature for drying of *Pangasius* surimi into its powdered form was achieved during its exposure at temperature of 60^{O}C.

KEY WORDS: *Pangasianodon hypophthalmus,* dry surimi powder, drying temperature, biochemical and microbial quality, sensory evaluation.

INTRODUCTION

Demands for fish protein ingredients including dried fish protein to develop functional food or ready-to-eat products are gradually growing in the world (Thorkelsson *et al.,* 2009). The white flesh and low-fat content fish are considered the most suitable species for developing fish protein ingredients (Hultin *et al.,* 2005; Park and Lin, 2005), while, there are other fish protein sources that can be used for producing protein ingredients such as dark muscles/underutilized/low value fish species and fish by-products for human consumption (Arason *et al.,* 2009).

Minced meat, the most important ingredient for production of surimi and surimi-based products, is the flesh separated from the skin, bones, scales and fins of the fish. Surimi is a product of Japanese origin, derived from a traditional Japanese way of using and preserving fresh fish, refers to concentrated myofibrillar protein extracted from fish flesh by washing minced meat that has been separated from bones, skin, and guts (Santana *et al.,* 2012a). During washing with cold water, fat and other water-soluble contents are removed, whereas insoluble myofibrillar protein is isolated. After being mixed with a cryoprotectant, this protein is called surimi (Okada, 1992). The addition of cryoprotectants is required to retain the functional properties of the myofibrillar proteins. The most commonly used cryoprotectant in the surimi industry is a 1:1 mixture of sucrose and sorbitol at a concentration of 8%. Surimi generally comes in a block form and is stored in frozen condition. Surimi possess some important functional properties such as gel forming ability and water holding capacity (WHC) due to its content of myofibrillar protein that plays the most critical role during meat processing like stabilization of comminuted and restructured meat products (Zhou *et al.,* 2006). The physicochemical state of myofibrillar proteins affects the functionality of meat system and plays a direct role in determining the quality and value of processed meat (Li and Wick, 2001). Surimi is used as a raw material for preparation of number of value-added products such as fish sausage, cakes, cutlets, patties, balls, pastes, texturized products, etc. Today, surimi is a popular food item not only in Japan but also in many other countries due to its unique textural properties and high nutritional value (Park and Lin, 2005).

Surimi can be produced from both marine and fresh-water fish, including both white-muscled and dark-muscled fish, such as Alaska Pollock, blue whiting, croaker, lizardfish, sardine, tilapia and bigeye snapper (Nopianti *et al.,* 2010). Commonly, certain species are used due to their easy capture and low price. The use of alternative species in order to obtain surimi of good gel-forming ability is one of the aims of the fishing industry. As, freshwater fish are excellent sources of high-quality protein due to presence of well-balanced highly digestible essential amino acids (Karmas and Lauber, 1987), the surimi making ability of many freshwater species could be upgraded by manipulating processing techniques (Onibala *et al.,* 1997).

Pangasianodon hypophthalmus (Ali *et al.,* 2012), also known as *Pangasius sutchi* has been widely cultured and propagated among fish farmers and breeders especially in West Bengal and Andhra Pradesh. According to DADF, GOI, 2017, it is called as “GAME CHANGER” because of its domestication through extensive culture and large-scale production and become an important fishery due to its remarkable growth rate (attains almost 1 kg in 90 days) in Indian environment. *Pangasius* meat has high nutritive qualities and excellent sensory properties such as tender flesh, sweet taste, absence of fishy odour and spines, delicate flavour and firm texture when cooked; these are the attributes that favour consumer preference for sutchi catfish.

Recent research indicates that surimi could be converted to a dried form, surimi powder that can be kept without frozen storage. 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 (Green and Lanier, 1985). Surimi powder can be prepared from frozen surimi blocks by adopting different drying technologies. The main purpose of drying technologies developed in food industries is to prolong the shelf life of a food product by dewatering, which means removing liquid water from the product (Chen, 2008). In thermal drying, energy transferred from the environment is used to evaporate the moisture from the product's surface, followed by the transfer of internal moisture to the surface of the product. As both drying and heating can lead to protein denaturation (Carjaval *et al*., 2005), the heating temperature of evaporation can be lowered by lowering pressure using vacuum for heat-sensitive material such as protein (Menon and Mujundar, 1987). Available drying methods for making surimi powder include freeze drying, spray drying, oven drying, solar drying, and mechanical drying (Santana *et al.*, 2012b); where the heating temperature of evaporation can be lowered by lowering pressure using a vacuum to prevent the protein from heat denaturation.

The freeze-drying process removes water from the matrix at a very low temperature (–50 to –70^{O}C) via the sublimation of frozen water to vapor in a vacuum chamber (Ratti, 2008). Although being more expensive than air drying (Ratti, 2008), freeze-drying is considered to be the most suitable for inhibiting protein denaturation compared to other drying methods (Liapis, 1987). Musa *et al.* (2005) reported that freeze-dried surimi powder from different fish species has superior functional properties. The spray-drying method removes water from products through spray–air contact. Masters (1976) defined spray drying as the transformation of fluid (solution, suspension, or paste) material to a dried form (powder, granule, or agglomerate) by spraying it into a hot drying medium resulting in the evaporation of the moisture. Shaviklo *et al.* (2010) used a mixture of saithe surimi and water (5× weight) to obtain a solution with about 3% dry matter for feeding into the spray-dryer machine with inlet and outlet temperatures of 190 ± 5^{O}C and 95 ± 5^{O}C, respectively. The freeze-dried surimi powder made from saithe had better functional properties than spray-dried powder (Shaviklo *et al.*, 2010). The processes involved in low-cost oven drying technology for developing dried fish protein are heating, drying and baking (Menon and Mujumdar, 1987). Arone *et al.* (2019) used both freeze drying and oven drying methods for preparation of dry surimi powder from surimi (itoyori), purchased from commercial industry. Other potential drying methods for producing surimi powder are solar drying and mechanical drying. Musa *et al.* (2002) reported solar dried surimi powder has acceptable functionality which was successfully used in food products such as soup mixing, high protein cereals products bread and macaroni supplementation and non-casein-based dairy type products.

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 (Santana *et al.,* 2012b). Another advantage of surimi powder is its usefulness in dry mixtures (Green and Lanier, 1985) that could help industries to modify the formulation of surimi-derived products, resulting in more homogenous blends and easier protein standardization. With the advancement of food technology, processing of surimi into dried form is flourishing so that it can be used in dry mixing. The purpose of the study is to establish and standardize the hypothesis that the functional properties of surimi powder from *Pangasius* is acceptable as a commercial preparation. Thus, the objective of the present study is to study the effect of drying temperature on the quality of dry surimi.

MATERIAL AND METHOD

Raw material

Live pangas also known as Sutchi Catfish (*Pangasianodon hypopthalmus*) were bought from the market by simple random sampling (Garia fish market, Kolkata) and used for the present study. The fishes were transferred to the laboratory within an hour from the market in iced condition and processed immediately.

Washing procedure for mince and production of surimi

Surimi production was carried out according to the method of Rawdkuen et al. (2009) as illustrated in Figure 1. The fish mince was washed with cold water ($40^{O}C$) using a mince to washing medium ratio of 1:4 (w/v) to remove sarcoplasmic proteins, blood, pigment, fat and other low molecular weight components. The mixture was continuously stirred for 10 minutes in a cold room ($40^{O}C$). The washed mince was then filtered through four layers of cheese-cloth and subsequently dewatered by using a hydraulic pressing machine. Washing was performed four times. The last washing step was carried out using 0.5% NaCl solution with mince to NaCl solution ratio of 1:4 (w/v). Finally, the meat was subjected to pressing and the final moisture content of the product was maintained about 79% level referred to as dewatered minced meat (DWM).

Production of surimi powder

Surimi samples were dried in three different drying temperature viz, 50^{O}C, 60^{O}C and 70^{O}C to prepare dry surimi powder (Figure 2), following the oven drying method Huda *et al.* (2012) with slight modifications.

The surimi powder was then subjected for proximate composition, biochemical, microbiological and sensory analysis to determine the suitable most drying temperature. Moisture content determination of the surimi powder was done by the method described by AOAC (1995). Total nitrogen was estimated by Kjeldahl method (AOAC, 1995). 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 (1959). The ash content was measured by the method of AOAC (1995). The surimi powder was then subjected in triplicate for Total Plate Count (TPC), physicochemical and sensory analyses. TPC was determined by spread plating appropriate dilutions on Total Plate Count Agar (Hi-media) (Nath *et al.,* 2014) and results expressed as log cfu/g. The physicochemical indices like TVBN, PV and pH of surimi powder were measured by the method described by AOAC (1995), by Folch *et al.* (1957) and by Ozyurt *et al.* (2009) (using pH meter Five Easy™ FE20, made by Mettler Todelo AG, Switzerland) respectively. Sensory evaluation was performed by a sensory panel composed of 15 experienced members based on 7-point hedonic scale as described by Siah and Tahir (2011).

All of the data were checked for normal distributions with normality plots prior to analysis of variance (ANOVA), to determine significant differences among means at $\alpha = 0.05$ level, using statistical tools of Microsoft Office Excel (2007) and R software (Version 2.14.1).

RESULTS AND DISCUSSION

In the present study, surimi powder was prepared from surimi of Sutchi Catfish (*Pangasianodon hypopthalmus*). Huda *et al.* (2012) prepared dried surimi powder from deboned, water-washed tilapia mince. The quality of surimi prepared from fish vary depending on species and on all those factors, which affect the composition of the fish like seasonal variation, feeding habit, pH of the habitat water, adaptation, temperature, lipid content, sex and spawning. In the present study, Sutchi Catfish (*Pangasianodon hypopthalmus*) was chosen due to easy availability and low price.

Surimi samples were dried in three different drying temperature viz, 50^{O}C, 60^{O}C and 70^{O}C to prepare dry surimi powder following the oven drying method Huda *et al.* (2012) with modifications. The drying process was continued overnight until the moisture content was reduced below 15% or less. The dried surimi was then milled into powder using conventional blender and sieved through a 30mm screen mesh. The powder thus obtained was packed in air tight container and kept under refrigeration (40^{O}C). Proximate composition, biochemical and microbiological analysis were done to determine the suitable drying temperature. Sensory assessment was also conducted to select the suitable temperature for drying.

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 (Majumder *et al*., 2017). In the present study, surimi was prepared by adding 4% sucrose, 4% sorbitol and 0.3% sodium tripolyphosphate. The final proximate composition for surimi powder obtained at 50^{O}C was 12.98±1.31%, 57.33±2.82%, 10.13±0.67%, 1.15±0.08% and 18.11±0.39% for moisture, protein, lipid, ash and carbohydrate respectively (Table 1). A significantly higher ($p<0.05$) value of ash (1.83±0.47%) was recorded in case of surimi powder dried at 60^{O}C than at 50^{O} and 70^{O}C. Drying temperature of 60^{O} and 70^{O}C was also found to significantly reduce the moisture content ($p<0.05$) as compared to 50^{O}C with 9.05±0.22% and 9.55±0.51% recorded value of moisture content for 60^{O} and 70^{O}C respectively. The drying temperatures within the range of 50^{O} to 70^{O}C, however do not seem to have any influence on the composition of protein, fat and carbohydrate ($p>0.05$).

Being protein as main constituent, surimi powder having more than 65% protein can be classified as a fish protein concentrate (FPC) as per FAO guidelines (Majumder *et al*., 2017). At 60^{O} and 70^{O}C the protein content observed was 60.86±1.61% and 61.04±1.31% respectively while the fat content was 10.53±0.23% and 10.65±0.85% respectively. The protein contents of tilapia and trout surimi powder were reported to be 57.8% and 64.8% respectively (Huda *et al.,* 2001a) which corroborates to the results of the present findings. Likewise, the protein content of surimi powder prepared from tilapia by oven drying method at 60±5^{O}C was reported to be 65.32±0.66% (Majumder *et al*., 2017). Similarly, a study conducted by Ramirez *et al.* (1999) 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.* (2001) 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 (17.66±0.59% at temperature of 60^{O}C) observed in the present study.

EIC (1995) recommended that TVBN value of 35 mg/100g in meat is considered as limit of acceptability, above which fishery products are considered unfit for human consumption. Lakshmanan (2000) recommended a level of PV in seafoods is 10 – 20 meq O_2/kg of fat as a limit of acceptability. The acceptable upper limit for the pH of fish is 6.8 – 7 (Ludorff and Meyer, 1973). International Commission on Microbiological Specification for Foods recommended that the TPC value exceeding 6 log cfu/gm is regarded as microbiologically spoiled fish muscle, unsafe for human consumption (ICMSF, 1988). The quality parameters such as TVB-N, PV, pH and TPC (Table 2) were all found to be well within the recommended level of acceptability as indicated earlier except for the surimi powder prepared at the drying temperature of 50^{O}C, wherein the TVBN crossed the limit of acceptability reaching a value of 36.24±1.26 mg/100g. Based on the TVBN values, the temperature of 50^{O}C was inferred to be not suitable for the drying of surimi. However, considering the values of TVBN, PV, pH and TPC it was difficult to select between the drying temperatures of 60^{O} and 70^{O}C as the values for all these parameters were within acceptable limits for both the temperatures. Therefore, the final selection of drying temperature was done based on sensory scores of the surimi powders (Table 3).

Drying temperature was found to affect the colour of the surimi powder with the optimum acceptable colour score achieved at 60^{O}C (6.38±0.52). At higher temperature of 70^{O}C darkening was observed with consequent decrease in the colour scores (5.75±0.46). High temperatures during drying were found to exert a great influence on degrading the colour of surimi powder which may be due to Maillard reaction that leads to reduction of the lightness value (Musa *et al.,* 2005). Maillard reaction progresses faster at higher drying temperatures. Furthermore, addition of cryoprotectant in different percentage during surimi preparation may affect the colour score of dried surimi due to Maillard reaction (Musa *et al.,* 2005). Using low temperature to prepare surimi powder with cryoprotectant addition could protect protein denaturation during drying process (Musa *et al.,* 2005).

Therefore, considering the overall acceptability score the drying temperature of 60^{O}C (6.25±0.24) was adjudged suitable for preparation of pangus surimi powder. Huda *et al.*

(2000) reported that a drying temperature of 60^{O}C was the best drying temperature which brings the moisture content less than 10% in Fish Protein Concentrate after 12 hours of drying. Majumder *et al*. (2017) also prepared tilapia surimi powder by oven drying at 60±5^{O}C temperature until the moisture content reaches below 15%. Nath and Singh (2019) successfully prepared dry surimi powder from Sutchi Catfish (*Pangasianodon hypopthalmus*) by oven drying method at 60^{O}C and the residual moisture content was found to be11.47±0.58%. Thus, we can conclude from the following study that the best temperature for drying of *Pangasius* surimi into its powdered form was achieved during it exposure at temperature of 60^{O}C assessing its sensory characteristics, though having no change in its protein, fat and ash values.

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Table 1. Proximate composition of surimi powder at different drying temperature

Parameters \ Drying Temperature	50°C	60°C	70°C
Ash (%)	1.15±0.08[a]	1.83±0.47[b]	1.25±0.10[a]
Moisture (%)	12.98±1.31[a]	9.05±0.22[b]	9.55±0.51[b]
Fat (%)	10.13±0.67[a]	10.53±0.23[a]	10.65±0.85[a]
Protein (%)	57.33±2.82[a]	60.86±1.61[a]	61.04±1.31[a]
Carbohydrate (%)	18.11±0.39[a]	17.66±0.59[a]	17.61±0.69[a]

**Results are mean of 5 determinations with s.d.*
#Values of mean within the same row with different superscripts vary significantly ($p<0.05$)

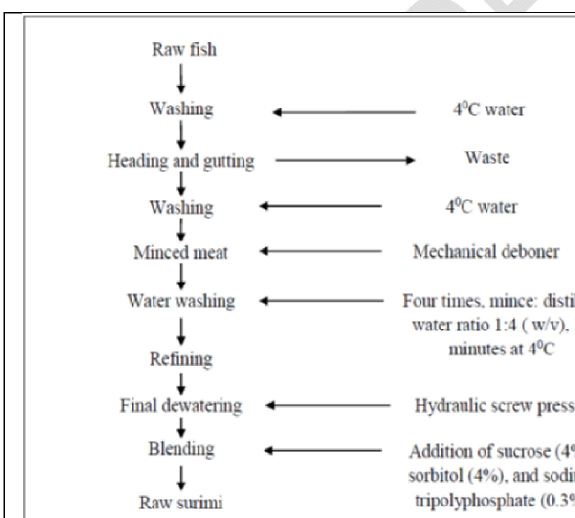
Table 2. Biochemical and microbiological analysis of surimi powder at different drying temperature

Parameters \ Drying Temperature	50°C	60°C	70°C
pH	6.60±0.02 [a]	6.70±0.04 [b]	6.80±0.06 [c]
TVBN (mg/100g)	36.24±1.26 [a]	27.40±0.35 [b]	14.68±0.33 [c]

Table 3. Sensory analysis of surimi powder at different drying temperature

Drying Temperature / Parameters	50⁰C	60⁰C	70⁰C
Colour	5.88±0.83	6.38±0.52	5.75±0.46
Flavour	6.13±0.64	6.13±0.35	5.63±0.52
Texture	5.75±0.46	6.25±0.46	5.88±0.35
Overall Acceptability	5.92±0.30	6.25±0.24	5.75±0.30

**Results are mean of 5 determinations with s.d.*
#Values of mean within the same row with different superscripts vary significantly (p<0.05)



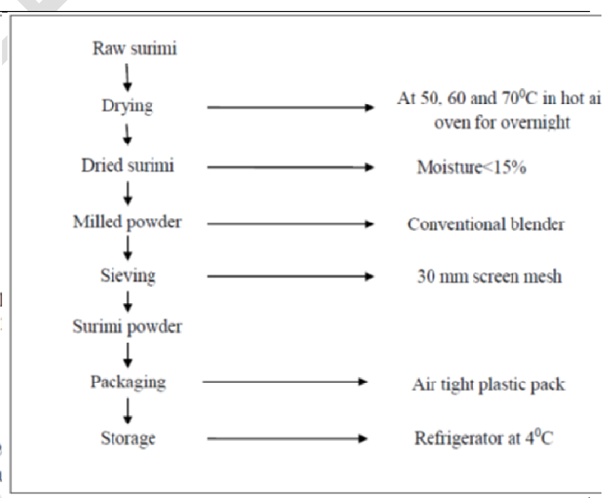


Figure 1. Flow diagram of surimi processing **Figure 2. Flowchart of surimi powder preparation**