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Fortification of Noodles using Tilapia Surimi Powder

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ABSTRACT
Commercial noodles are rich in carbohydrates, but deficient in essential nutrients, such as proteins, dietary fiber and vitamins. The protein enrichment in noodles can be achieved by addition of fish surimi powders, which are protein concentrates. Surimi is concentrated myofibrillar protein extracted from fish flesh by washing process. Surimi powder is the dried form of surimi which offers the advantages of easy handling, low distribution cost, and physically convenient for addition to dry mixtures. Surimi powder can be used to substitute flour in formulation of noodles. Five different levels of surimi powder (0%, 5%, 10%, 15% and 20%) were substituted in the flour used. Proximate composition, cooking properties, color, pH and sensory analysis were conducted on noodle formulations. Ash, protein and fat content showed a significant ($p<0.05$) increase with increase in fortification levels. Cooking yield and color parameters like lightness, redness, yellowness also showed similar increasing trends ($p<0.05$) as the levels of surimi powder increased except for pH. The results of the sensory scores revealed that at fortification levels above 15%, the acceptance of the noodles reduced based on color, flavor, texture and overall acceptability. So, a fortification level of 15% surimi powder was optimised for incorporation into the noodles.

Keywords - Fortification, Noodles, Surimi, Surimi powder, Tilapia

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I. INTRODUCTION

Surimi is obtained by washing fish mince with water resulting in a product containing mainly myofibrillar proteins (Pietrowski et al., 2011). Surimi protein is rich in lysine, which is usually deficient in cereal grains. The deficiency of lysine leads to the poor utilization of protein and thus results in protein malnutrition. In addition, surimi contains unsaturated fatty acids, such as linoleic acid, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which reported to be able to reduce the risk of coronary heart disease, decrease triglyceride, blood pressure and improve endothelial function (Juturu et al., 2008). Calcium, zinc, phosphorus and other minerals are also found in surimi (Auh et al., 2003). Therefore, surimi is suitable enrichment material for noodle and other cereal products. Recent research indicates that surimi could be converted to a dried form, surimi powder, which can be kept without frozen storage. Dried surimi is quite similar to fish protein concentrate (FPC) particularly with respect to high protein content (Niki et al., 1992). 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. Compared to frozen surimi, powdered surimi offers many advantages in commercial food production, which includes ease of handling, lower distribution cost, easy to store and useful in dry mixes application. One of the potential utilization of surimi powder is in the formulation of noodles. Currently, commercial noodles are rich in carbohydrates, but deficient in essential nutrients, such as proteins, dietary fiber and vitamins. For example, the protein deficiency problem could be solved by consuming noodles with foods that are rich in protein or by enriching noodles with protein. The protein enrichment can be achieved by the addition of dried meat powders, such as fish surimi powders, which are protein concentrates (Huda et al., 2000; Park, 2005). Previous studies on the addition of dried minced fish to noodles have been performed from *Nemipterus* sp. and *Oreochromis mossambicus* (Yu, 1990), the supplement of wet minced fish and surimi from *Decapterus macrosoma* and *Congresox talabon* (Peranginangin et al., 1995) and the incorporation of wet washed fish minced from *Oncorhynchus mykiss* (Setiady et al., 2007). However, to our knowledge, there has not been a study performed on the incorporation of surimi powder into noodles. Hence, the incorporation of dried surimi powder prepared from Tilapia (*Oreochromis mossambicus*) into noodles is important to meet a void in research.

II. METHODOLOGY

2.1. Sample collection

Fresh live Mozambique tilapia having an average bodyweight of 370.20±2.41g and length of 25.66±1.08cm were obtained from local fish market. They were packed in ice and brought to department of Fish Processing Technology under hygienic condition.

2.2. Processing of surimi

Surimi can be defined as a wet concentrate of fish muscle, that is mechanically deboned, water washed and mixed with cryoprotectants for a good frozen shelf life. Generally fish can be processed to surimi using four steps: 1) Separating fish flesh 2) water washing 3) adding cryoprotectant 4) freezing.

2.3. Preparation of washed mince

Surimi production was carried out through 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. (2009). 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.

2.4. 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 at -40^0C as blocks using a plate freezer. The frozen samples referred to as 'surimi' were kept under frozen storage at -18^0C till processing.

2.5. Production of surimi powder

Surimi powder was prepared according to the method used by Huda et al. (2001) and Majumder et al. (2017). Surimi blocks made from tilapia were taken out from the frozen storage and thawed and cut into pieces and placed in 50x30 cm aluminum trays. Tilapia surimi was processed into surimi powder by drying using hot-air conventional oven at $60±5^0$C for 12 hrs. The surimi was dried until the moisture content reached 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.

2.6. Yield study

Yield of dewatered meat was calculated based on the weight of mince meat during all three washing cycles. Yield of raw surimi (after blending with cryoprotectants) was estimated based on the total weight of mince meat and dewatered meat respectively. Percentage of yield of surimi powder was also evaluated based on the total weight of raw surimi.

2.7. Preparation of noodles

The noodles were prepared using Kent noodle and Pasta maker with different percentages of surimi powder (SP), i.e., 0% (SP0); 5%(SP5); 10% (SP10); 15% (SP15) and 20% (SP20), as shown in Table 1. All treated noodles were analyzed for proximate composition, cooking properties and sensory properties.

Table 1. Formulations with different levels of surimi powder incorporated into the noodles

Material (%)	SP0	SP5	SP10	SP15	SP 20
Wheat flour	100	95	90	85	80
Surimi powder	0	5	10	15	20
Kansui	1	1	1	1	1
Salt	2	2	2	2	2
Potato starch	8	8	8	8	8
Distilled water	34	34	34	34	34

The noodles were pre-cooked in boiling water for 1 min, with a ratio of at least 1:10 noodles to water (Kruger et al., 1996; Lim, 2006; Ramli et al., 2009). The partially cooked noodles were subsequently rinsed with cool tap water. The cooked noodles were left to cool at room temperature. The partially cooked noodles were then ready for analysis.

2.8. Proximate composition, Color and pH value

The noodles were analyzed for moisture, protein, fat and ash content using standard procedures AOAC (2000). The color of the noodles was determined using spectrocolourimeter (Colourflex EZ, Hunter associates Laboratory, Inc, Reston, VA) with illuminant of D 65/10°.This instrument was calibrated with black and white reference tiles before analysis. The CIELAB (L*, a*, b*) colour scale was used for the study.. The pH of cooked noodle slurry was measured using a pH meter, which was calibrated using buffered solutions of pH 4.0 and 7.0 (Ramli et al., 2009).

2.9. Cooking yield

Cooking yield was determined as described by Alesson-carbonell et al. (2005). Noodles were weighed before and after cooking. Cooking yield is calculated as follows:

Cooking Yield (%) = (Weight of noodles after cooking/Weight of noodles before cooking) x100

2.10. Estimation of cooking loss:

Cooking loss was determined following the method of AACC (1976). The cooking water was separated from the cooked noodles, and the cooking water was poured into a 250 ml of volumetric flask; the volume was then topped off with distilled water. The volumetric flask was shaken to homogenize the cooking water solution. A 10 ml aliquot of the solution was pipette into an aluminium dish, and the sample was dried in an oven at 105°C until a constant weight was obtained. The cooking loss was measured by the equation below:

$$\text{Cooking loss (\%)} = \frac{A - B}{(\text{Noodle sample weight-C})} \times 100\% \quad X\ 25$$

where
A= weight of aluminum dish + dry cooked water sample
B= weight of aluminum dish
C= noodles moisture content

2.11. Sensory evaluation

Five types of noodle samples were boiled and cut into 10 cm pieces. Sensory evaluation of cooked noodles was performed by a sensory panel composed of 15 experienced members. They were required to evaluate the noodles based on the colour, flavor, texture and overall acceptability using a 7-points hedonic scale: 1 = dislike very much, 2 = dislike moderately, 3 = dislike slightly, 4 = neither like nor dislike 5 = like slightly, 6 = like moderately, and 7 = like very much (Siah and Tahir, 2011).

2.12. Statistical Analysis

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 α = 0.05 level, using statistical tools of R software.

III. RESULTS AND DISCUSSION

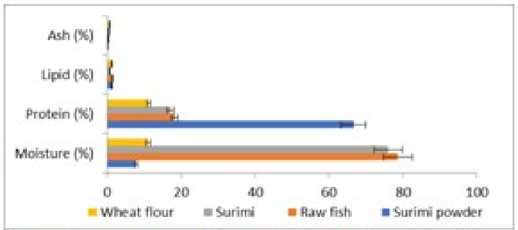
The average total length and round weight of the experimental fishes were 25.66±1.08 cm and 370.2±2.41 g respectively which is higher than that reported by Majumder et al., 2017 wherein average total length and round weight was 23.5±1.08 cm and 248.3±3.42 g respectively. This could be due to the variations 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 2.

Proximate composition (Figure 1) of wheat flour, raw fish, surimi and surimi powder was analyzed. The results obtained for wheat flour are in good agreement with the results earlier reported by Singh et al.,2005. The values for moisture, protein, lipid and ash content are 78.65±0.03%, 18.2±0.02%, 1.48±0.05% and 0.15±0.01% respectively in raw fish which is fairly consistent with the findings of Majumder et al., 2017 for tilapia. Protein content of 17.12±0.02 % was obtained for surimi which is fairly consistent with the results of Majumder et al., 2017. Hossain et al.,2004 showed that fresh silver carp and pangus surimi contain 16.12% and 16.8% crude protein respectively. 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. The final proximate composition for surimi powder obtained was 7.75±0.005%,

Table 2: Yields (%) during production steps of surimi and surimi powder

Processing steps	**%**
Whole fish	100.00±0.00
Fillets to whole fish	33.80±0.15
Head to whole fish	25.33±0.01
Viscera, bones, scales to whole fish	39.66±0.03
Minced flesh to fillets	97.73±0.01
Washed mince to minced flesh	53.07±0.02
Surimi to whole fish	32.13±0.46
Surimi to fillet	44.77±0.16
Surimi to washed mince	86.31±0.02
Surimi powder to surimi	31.54±0.08

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



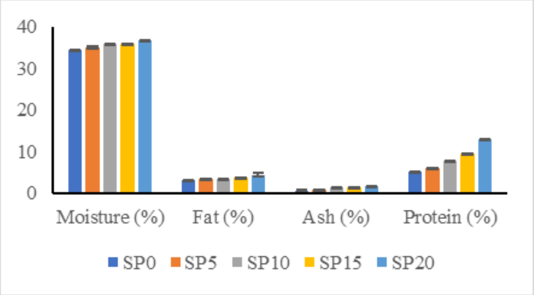
*Results are mean of three determinations (n=3) with s.d.

Figure 1: Proximate composition of surimi powder and raw fish

66.64±0.073%, 1.14±0.01%, and 0.07±0.015% for moisture, protein, lipid and ash respectively which is fairly consistent with the result obtained by Majumder et al., 2017. The protein contents of tilapia and trout surimi powder were 57.8% and 64.8% respectively (Huda et al., 2001). 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.

3.1. Changes in proximate composition, of fortified noodles

Figure 2 shows the proximate compositions of the SP0, SP5, SP10, SP15 and SP20 samples. Replacing flour with surimi powder showed a significant improvement ($p<0.05$) in protein content from 5.27±0.005% to 13.08±0.07%. Similar trends have also been reported with fish minced noodles (Yu, 1990) as well as with boiled and dry noodles supplemented with surimi or minced fish (Peranginangin et al., 1995). The surimi powder primarily consists of myofibrillar proteins, while wheat flour contains comparatively a lower amount of protein. Hence, surimi powder could make a significant contribution of protein to noodles. Fat and ash content also increased significantly ($p<0.05$) reaching figures of 4.46±0.48% and 1.61±0.01% respectively for SP20 samples. The fat content showed a significant increase ($p<0.05$) in all the noodle samples that had been supplemented due to the remaining fat in the surimi powder. Although most of the fat in the surimi has already been removed during the washing step, the residual fat in the surimi powder might have contributed a certain amount of fat to the noodles. The ash in the surimi-substituted noodles significantly increased ($p<0.05$) when 15% surimi powder was added to the noodles. The ash consisted of minerals in the surimi powder, i.e., phosphorus, sodium, potassium, and magnesium (Dallas, 2004-2006). The moisture content of the noodles significantly increased ($p<0.05$) when the surimi powder was added in excess of 15% reaching a value of 36.82±0.03% for SP20 samples. The surimi might have increased the levels of water absorption rates due to its water holding capacity (Zayas, 1997) during the mixing and cooking steps.



*Results are mean of six determinations (n=6) with s.d.

Figure 2: Proximate composition (%) of noodles incorporated with surimi powder

3.2. Changes in pH

The pH of the noodles was significantly reduced ($p<0.05$) when supplemented with different levels of fish surimi powder (Table 3). A similar trend was reported by Yu (1990). The typical pH value of yellow alkaline noodles ranges between 9 and 11 (Kruger et al., 1996). The pH of surimi is 6-7 (Lin and Park, 1998) or 6.97- 7.06 (Sakura et al., 1993). Because the surimi has a nearly neutral pH, the pH of the yellow noodles was expected to possibly drop after the surimi powder was incorporated.

Table 3. Cooking properties and pH of noodles incorporated with surimi powder

Sample	Cooking Yield (%)	Cooking Loss (%)	pH
SP0	160.80±0.05	19.46±0.005	6.91±0.01
SP5	180.67±0.58	18.92±0.02	6.70±0.01
SP10	183.00±4.36	12.52±0.02	6.63±0.01
SP15	197.33±0.58	15.30±0.005	6.44±0.01
SP20	182.33±0.58	15.75±0.005	6.43±0.06

*Results are mean of six determinations (n=6) with s.d.

3.3. Cooking Properties

The cooking properties were tested and consisted of the cooking yield and cooking loss (Table 3). The cooking yield was defined as the percentage of noodle weight after cooking to the weight of the raw noodles. Hence, it represented the ability of the noodles to absorb water from the cooking medium. A higher value for the cooking yield and a lower cooking loss typically represents good-quality noodles. As seen in Table 3, the incorporation of surimi powder into noodles significantly increased ($p<0.05$) the cooking yield upto 15% SP fortification level (197.33±0.58%) then gradually decreased. Similar trends have also been reported by Chin et al., 2012. This result might have been due to the presence of surimi powder in the noodles. The surimi powder is hygroscopic and might have had the ability to absorb and hold water during heat treatment (Zayas, 1997). During the cooking process, the surimi content in the surimi-substituted noodles might have also gelatinized in addition to the starch. The gelatinization of both surimi and starch during the cooking process might have contributed some water, which increased the weight of the noodles after cooking.

The cooking loss represented the particles that diffused out from the noodles into the cooking medium during cooking. The cooking loss property reflects the surface characteristics of the noodles. According to Shiau and Yeh (2001), the higher the cooking loss is, the stickier the noodle surface. High cooking loss is undesirable because it means that there was a high starch content in the cooking medium and that the noodles had a low cooking tolerance (Chakraborty et al., 2003). Cooking loss of noodles is attributed to the interactions of protein and starch in the presence of water (Güler et al., 2002). The cooking loss (%) was highest for noodles without fortification (SP0) and gradually decreased with the least value of 12.52±0.02% for SP10. The decrease of cooking loss with the addition of surimi may be due to the formation of gel network structure between starch and protein during heating process, which prevents leaching of starch.

3.4. Color analyses

The color of the boiled noodles is presented in Table 4. The color of the noodles is the most vital quality parameter. Results were expressed as L* (brightness), a* (redness) and b* (yellowness). L* values measure black to white (0–100); a* values measure redness when positive and greenness when negative; b* values measure yellowness when positive and blueness when negative. The L* values showed a decreasing trend for samples SP15 (50.03±2.08) and SP20 (48.26±1.00) when compared to SP0 (55.63±1.81). This suggests a reduction in whiteness at higher levels of incorporation. The scores of a* is positive for all samples indicating redness and b* values ranged from a positive value of 20.24±1.06 in SP0 to 22.52±0.31 in SP15. The b* values indicates yellowness in all samples with highest values in SP10 and SP15. Alkaline noodles should have a clear yellow color without any spots and discolorations. The yellowish color of the noodles is attributed to the presence of natural flavonoid pigments, which are colorless at acidic pH levels but turn yellow at alkaline pH levels (Fu, 2008). The color of the partially cooked noodles was analyzed after the noodles were produced. Desirable alkaline noodles have high positive values for b*. The color of the different levels of surimi powder-substituted noodles was roughly distinguished by the eyes. Due to the hygroscopic property of surimi powder, it might have absorbed much of the free water and lowered the water activity a_w of the noodles. The decreasing value of a_w decreased the browning activity of the polyphenol oxidase enzyme, which is present in noodles; hence, it helped lighten the color of the noodles. During the washing step, almost all of the red blood cells were washed and removed from the surimi. However, some blood still remained in the surimi powder, which might have contributed to some of the red color of the surimi substituted-noodles. A significant increase ($p<0.05$) in the yellow color was observed when the surimi powder reached 15% in the noodles due to the non-enzymatic Maillard reaction of amino acids between the myofibrillar proteins and the reducing sugars from the cryoprotectant. Here 15% SP fortified noodles shows significantly ($p<0.05$) higher yellowness values which are 22.52±0.31. The reducing sugars react with proteins and produce yellow-browning compounds through the Maillard reaction during mild heating (70-100°C) (Billaud et al., 2004). The yellow-browning Maillard reaction could have occurred during the production of the surimi powder, which contributed to the yellow color of the surimi substituted noodles.

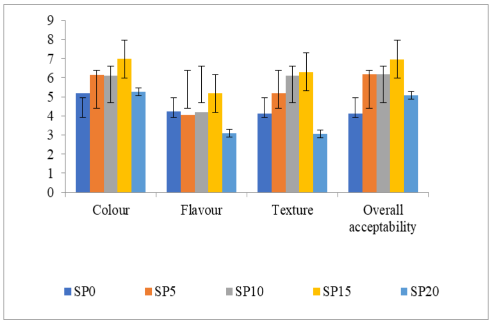
Table 4: Color analysis of fortified noodles

	L*	a*	b*
SP0	55.63±1.81	5.26±0.45	20.24±1.06
SP5	56.36±3.65	5.00±0.51	21.79±1.07
SP10	56.81±2.22	5.20±0.32	22.18±1.27
SP15	50.03±2.08	5.33±0.05	22.52±0.31
SP20	48.26±1.00	5.80±0.09	20.28±0.44

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

3.5. Sensory evaluation

The sensory evaluation results (Figure 3) showed that there were significant reductions ($p<0.05$) in the color, texture, flavor and overall acceptability as noted by the panelists when the substitution of surimi powder reach 20% from 15%. The panelists failed to differentiate between SP0 and SP5. All sensory attributes of SP15 noodles were significantly the highest ($p<0.05$) among all samples; the SP0 noodles showed the lowest score among all samples in all sensory attributes. The increase in surimi powder from 15% to 20% contributed to a higher fishy smell, taste and after taste to the noodles as well as a softer and less elastic texture; these characteristics might not have been favourable to the panellists, especially for those who dislike seafood.



*Results are mean of fifteen determinations (n=15) with s.d.

Figure 3: Sensory scores of surimi powder fortified noodles

IV. CONCLUSION

The incorporation of surimi powder (SP) had an impact on the proximate composition, color, cooking properties, pH and sensory properties of noodles. The incorporation of surimi powder significantly increased ($p<0.05$) the ash, protein, fat, lightness, redness, yellowness, cooking yield as the levels of surimi powder increased. In case of 15% SP fortified noodles a gradual increase in scores of overall acceptability was observed which decreased when it reached 20% SP fortified noodles. Similar trend was observed for all the individual parameters of color, texture and flavor. Although 20% fortified noodles have higher protein, lipid, fat and cooking yield but based on sensory score it may be concluded that noodles fortified at 15% with dry surimi powder from tilapia (SP15) gave best acceptability.

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