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Research Article

Effect of tilapia surimi powder incorporation on physical properties of semolina flour pasta

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Abstract

Demand for healthier food products is increasing all over the world, and cereal food industry has attempted to enhance the nutritional content of products by the addition of protein and lipid-rich ingredients. Incorporation of fish proteins rich in amino acids, specially lysine and methionine, through partial substitution of semolina flour is expected to improve the nutritional value of pasta. The present study is focused on the effect of such incorporations on the physical properties like texture profile, colour, cooking properties, water absorption and swelling index. Surimi powder (SP) prepared from tilapia (*Oreochromis mossambicus*) was used for the study. Four replacement levels were tested T5 (5%), T10 (10%), T15 (15%) and T20 (20%) together with a control pasta, T0 (100% semolina flour). The results demonstrated an increase in cooking yield (158.18±0.82% in T5 to 175.31±3.31% in T20) and cooking loss (3.98±0.12% in T5 to 5.26±0.17% in T20) and all pasta samples were in the acceptable range (8 g/100 g) for cooking loss. The addition of SP resulted in significantly ($p<0.05$) decreased swelling index and water absorption, with an increase in hardness from 73.13±34.11 g (T5) to 128.21±8.88 g (T20). Instrumental colour parameters indicated that T10 to T20 had better yellowness than T0 and T5. Thus, pasta can be fortified using surimi powder, characterized with increased hardness and fracturability. The fortification levels above 5% i.e., treatment T10 to T20 will be preferred more due to better yellowness.

Keywords: Cooking properties, Pasta, Surimi powder, Texture

Highlights

- Pasta was fortified with tilapia surimi powder through partial replacement of semolina flour.
- Four replacement levels were tested T5 (5%), T10 (10%), T15 (15%) and T20 (20%).
- Significantly higher yellowness (b*) was observed at fortification levels higher than T5.

INTRODUCTION

Pasta is a popular food item among consumers largely due to its nutritional properties, ease of preparation and cheap price (Foschia *et al.*, 2015). Pasta is prepared from wheat or semolina flour which in turn is known to be low in amino acids lysine and methionine (Gobbetti and Ganzle, 2013). Therefore, it becomes necessary to fortify pasta with proteins from sources rich in essential amino acids (Nogueira and Steel, 2018). Fish is an excellent source of protein and can be used for fortification of pasta (Kris-Etherton *et al.*, 2002). Fish is generally incorporated in different value-added products in the form of mince and surimi. Surimi is the concentrated myofibrillar protein extracted by washing fish mince and added with cryoprotectants (Santana *et al.*, 2012). Surimi is frozen and stored in frozen storage till further application, which involves high costs related to storage and distribution (Parvathy and George, 2014). This drawback of surimi can be offset by converting surimi to a dried form called surimi powder. Surimi powder is ideal for the development of food products (Park and Lin, 2005) and may be a good raw material for fortification of pasta. In the present study, the effect of incorporation of tilapia (*Oreochromis mossambicus*) surimi powder through partial replacement of semolina flour on the physical properties of pasta like texture profile, colour, cooking

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properties, water absorption and swelling index were studied.

MATERIALS AND METHODS

Preparation of dry surimi powder: Fresh tilapia fish (*Oreochromis mossambicus*) were purchased from Garia fish market, Kolkata by simple random sampling. The fishes were transferred to the laboratory within an hour in iced condition and processed immediately. Surimi was prepared following the procedure described by Rawdkuen *et al.* (2009). The fish mince was washed in cold water (4ºC) using a mince/washing medium ratio of 1:3 (w/v). The mixture was stirred continuously for 10 minutes in a cold room maintaining a temperature of 4^{o}C. It is then filtered through four layers of cheese-cloth and dewatered by using a hydraulic press. The steps were repeated thrice, and in the third washing step, 0.5% NaCl solution was added, with mince to NaCl solution ratio of 1:3 (w/v). Finally, the meat was dewatered by pressing to a final moisture content of 79% and mixed with sucrose (4%), sorbitol (4%) and sodium tripolyphosphate (0.3%) in a silent cutter. Surimi was frozen as blocks at -40±1^{o}C and stored at -18±1^{o}C.

For preparation of surimi powder, frozen blocks of surimi were thawed for 4 hours, cut into pieces and placed on aluminum trays in a conventional hot air oven at 60±5°C temperature until the moisture content was below 15% (Huda *et al.*, 2012). The dried surimi was milled to powder with a blender and sieved through a 30 mm screen mesh packed in airtight zip lock packs and stored at 4ºC for further use.

Fortification of pasta with surimi powder: Different percentages of surimi powder (SP), i.e., 0% (T0); 5% (T5); 10% (T10); 15% (T15) and 20% (T20) were used during the preparation of pasta by partial replacement of semolina flour. Different levels of semolina flour and surimi powder were taken in the plastic basin of the pasta maker machine. For each batch of pasta, 500 g of dry ingredients and 170 mL of water (room temperature) were added. Mixing was carried out for 20 min, and then the machine was switched to extrusion mode. The long strands of uniform thickness (3.5 mm) were collected after cold extrusion on a plastic food tray and cut into lengths of 10-12 mm (Desai *et al.*, 2018). The un-dried pasta samples were kept in zip lock bags and stored at ambient temperature (24°C) for further study.

Texture profile analysis of fortified pasta: The textural properties of undried pasta were determined using a TA-XT plus texture analyser (Stable Micro System, Surrey, UK) equipped with a 5 kg load cell and compression plate (P/75, 75 mm Ø). Texture analyser settings used were: Mode: Texture Profile Analysis 2 (return to start); Pre-Test Speed: 3 mm/s; Test Speed: 1 mm/s; Post-Test Speed: 10 mm/s; distance: 50% in compression mode; Time: 1 s; Data acquisition rate: 200 pps. From the TPA curve, hardness, cohesiveness, springiness, gumminess, chewiness, and resilience were obtained as suggested by Jalgaonkar *et al.* (2018).

Instrumental colour parameter of fortified pasta: The colour of the undried pasta samples (L*, a*, and b*) was measured by using a Model Spectro-guide 45/0 gloss (maker: BYK Gardner, Gerestried, Germany).

Physical characteristics of fortified pasta: The cooking time is the minimum time necessary to gelatinize the starch. Undried pasta strands (20 g) were cut into equal lengths of 40 mm and cooked in 300 mL of boiling water. During cooking, the optimal cooking time (OCT) was evaluated by taking a sample strand of pasta every 30 seconds. The time of disappearance of the core of pasta was observed by squeezing it between two transparent glass sides and recorded as described in the AACC approved method 66-50 AACC (2000). The time at which the core completely disappeared was taken as the optimal cooking time (Jalgaonkar *et al.*, 2018).

The cooking yield was determined as described by Aleson-Carbonell *et al*. (2005). The pasta was weighed before and after cooking. Cooking yield is calculated as follows: Cooking Yield (%) = (Weight of pasta after cooking/weight of pasta before cooking) x100.

For determination of cooking loss (%), 10 g of pasta was placed into 300 mL of boiling distilled water in a 500 mL beaker. After cooking for respective OCT, the samples were taken from the beaker and weighed for cooking yield. The residue was determined by weighing the solid materials in cooking water after drying in an oven at 130°C overnight to a constant weight. Results were recorded as follows: Cooking loss (%) = Weight of residues in cooking water/Weight of uncooked sample x 100 (Olfat *et al*., 1993).

The swelling index (SI) of cooked pasta (g water/g dry pasta) was determined by adopting the procedure of Cleary and Brennan (2006). Pasta (10 g) was weighed after cooking and dried at 105°C to a constant weight. The swelling index was expressed as SI = (Wc – Wd)/ Wd, where Wc is the weight of cooked pasta (g), and Wd is the weight of pasta after drying (g).

Ten gram of pasta was cooked in 300 mL of boiling water at an optimal cooking time for estimation of water absorption index (Foschia *et al*., 2014). The water absorption index (WAI, g/100 g) was estimated as WAI = (Wc -Wr)/Wr × 100, where Wc is the weight of cooked pasta (g), and Wr is the weight of uncooked pasta (g).

Statistical analysis: All the data were checked for normal distribution with normality plots prior to analysis of variance (ANOVA) to determine significant differences among means at $\alpha = 0.05$ level, using the statistical tool of R software (Version 2.14.1). Tukey HSD was done to determine significant differences between treatments.

RESULTS

Texture profile analysis of fortified pasta

Texture profile parameters of pasta were assessed based on hardness, springiness, fracturability, cohesiveness, gumminess, chewiness and resilience (Table 1). The values of hardness exhibited a significant degree ($p<0.05$) of increase from 58.70±16.67 g in T0 to 128.21±8.88 g in T20. In the present study, the fracturability was found to be significantly higher ($p<0.05$) (133.62±10.24 g) in T20 sample as compared to T0 (60.24±16.92 g). The springiness value for the control as well as the fortified pasta were not significantly different at $p<0.05$, with values ranging from 0.95±0.04 in T15 to 0.98±0.02 in T5.

Similar to springiness, no significant variations were observed for cohesiveness among the samples. Cohesiveness can be used to indicate the adhesion within the sample (Yang *et al*., 2018), which is highest in the control sample T0 (0.90±0.02) and lowest value in sample T15 (0.75±0.11). In control samples, the gumminess was recorded as 53.16±15.92, which is significantly lower ($p<0.05$) than the gumminess value of sample T20 (100.79±8.76). A similar trend was observed for chewiness values ranging from 52.20±16.06 (T0) to 97.24±7.95 (T20). There were no significant variations ($p>0.05$) in resilience among the fortified pasta samples studied.

Table 1. Texture profile analysis of raw pasta at different fortification levels

Treatment	Hardness (g)	Fracturability(g)	Springiness	Cohesiveness	Gumminess	Chewiness	Resilience
T0	58.70±16.67^{a}	60.24±16.92^{a}	0.98±0.01^{a}	0.90±0.02^{a}	53.16±15.92^{a}	52.20±16.06^{a}	0.60±0.06^{a}
T5	73.13±34.11^{a}	74.68±35.11^{a}	0.98±0.02^{a}	0.82±0.05^{a}	59.98±28.02^{a}	58.62±27.35^{a}	0.56±0.09^{a}
T10	88.64±25.98^{b}	92.47±26.77^{b}	0.97±0.01^{a}	0.79±0.04^{a}	70.77±22.84^{b}	68.71±22.36^{b}	0.48±0.04^{a}
T15	98.80±31.57^{b}	73.34±48.11^{a}	0.95±0.04^{a}	0.75±0.11^{a}	74.77±26.82^{b}	71.37±27.23^{b}	0.45±0.03^{a}
T20	128.21±8.88^{c}	133.62±10.24^{c}	0.97±0.02^{a}	0.79±0.03^{a}	100.79±8.76^{c}	97.24±7.95^{c}	0.50±0.01^{a}

*Results are mean of five determinations (n=5) with s.d.; #Values of mean with different superscripts within the same column vary significantly ($p<0.05$) between the treatments

Table 2. Color characteristics of raw pasta at different fortification levels

Treatment	L*	a*	b*
T0	79.62±1.34[a]	1.39±0.22[a]	10.86±0.35[a]
T5	81.76±1.52[a]	0.89±0.04[a]	11.17±0.57[a]
T10	77.65±2.41[a]	1.51±0.52[a]	13.00±1.34[b]
T15	77.64±1.35[a]	1.46±0.18[a]	13.86±0.23[b]
T20	74.41±1.75[b]	1.27±0.17[a]	13.14±0.26[b]

*Results are mean of five determinations (n=5) with s.d.; ##Values of mean with different superscripts within the same column vary significantly ($p<0.05$) between the treatments

Instrumental colour parameter evaluation of fortified pasta

The L* value of the control sample (T0) was recorded as 79.62±1.34, which increased to 81.76±1.52 in sample T5 upon addition of 5% surimi powder (Table 2). Further fortification with surimi powder resulted in a decrease in L* value for samples T10, T15, and T20 suggesting decrease in lightness. The results indicate a significant ($p<0.05$) lowering in lightness in sample T20 as compared to other treatments. No significant difference ($p>0.05$) in redness values (a*) was observed among the samples. The yellowness of raw pasta samples was detected to increase with the increase in fortification of pasta with surimi powder. Significantly higher ($p<0.05$) yellowness (b*) was noticed in samples T10 to T20 as compared to T0 sample, although no significant variations ($p>0.05$) was observed among T5 and T0.

Cooking properties of raw pasta at different fortification levels

Water absorption index (WAI): The water absorption index gradually decreased from 68.24±0.99% in sample T0 to 52.21±1.32% in sample T20 (Table 3). The results revealed that the water absorption index of fortified pasta samples varied significantly ($p<0.05$) except between T15 and T20.

Cooking yield (CY) and cooking loss (CL): The cooking yield of raw pasta samples was detected to increase with the increase in fortification of pasta with surimi powder (Table 3). Significantly higher ($p<0.05$) cooking yield (CY) was noticed in samples T5 to T20 as compared to the T0 sample, although no significant variations ($p>0.05$) was observed between T5 - T10 and T20 - T15. The values varied from 158.18±0.82% in T5 to 175.31±3.31% in T20 (Table 3).

The cooking loss was significantly higher ($p<0.05$) in samples T10 to T20 as compared to T0 and T5 samples. The values varied from 3.98±0.12% in T5 to 5.26±0.17% in T20, suggesting that all samples were within the limit of acceptability of 8% for cooking loss.

Optimal cooking time (OCT): The control sample T0 had an OCT of 9.05±0.04 minutes (Table 3) which is significantly higher ($p<0.05$) than the samples (T10 and T15) fortified with tilapia surimi powder. Among the treated

Table 3. Cooking properties of raw pasta at different fortification levels

Treatment	WAI (%)	Cooking yield (%)	Optimal cooking time(min)	Cooking loss (%)	Swelling Index
T0	68.24±0.99[a]	151.81±1.19[a]	9.05±0.04[a]	4.02±0.24[a]	2.34±0.11[a]
T5	64.23±1.00[b]	158.18±0.82[b]	8.88±0.10[a]	3.98±0.10[a]	2.02±0.04[b]
T10	58.34±0.78[c]	165.65±2.35[b]	7.86±0.11[b]	4.34±0.11[b]	1.92±0.03[b]
T15	54.23±1.09[d]	170.39±1.39[c]	8.30±0.14[b]	4.76±0.42[b]	1.81±0.13[b]
T20	52.21±1.32[d]	175.31±3.31[c]	8.89±0.12[a]	5.26±0.17[c]	1.78±0.10[b]

*Results are mean of five determinations (n=5) with s.d.; #Values of mean within the same column vary significantly ($p<0.05$) between the treatments samples lowest OCT was observed in T10 (7.86±0.11 minutes), and OCT increased significantly ($p<0.05$) thereafter with an increase in surimi powder incorporation in pasta.

Swelling index (SI): From Table 3, it is evident that the swelling index gradually decreased from 2.34±0.11 in sample T0 to 1.78±0.10 in sample T20. The results also revealed that the swelling index of fortified pasta samples varied significantly ($p<0.05$) between control (T0) with samples fortified with tilapia surimi powder.

DISCUSSION

Fortification refers to the addition of single or multiple components to enhance the biological activity of the fortified food product (Lorusso *et al.*, 2017). Fish is an important protein source, and the incorporation of fish protein in the form of surimi powder in pasta is expected to achieve protein fortification as well as diversification of pasta. The fish species chosen for preparation of surimi powder was *O. mossambicus*. This is due to year-round availability and low price of the fish. The average length and weight of tilapia purchased from the market were 17.5±0.18 cm and 350.52±5.60 g, respectively. The total quantity of surimi powder produced was 156 g which was 2.34% of the whole tilapia processed during the study. This surimi powder was later used for fortification of pasta by replacing semolina flour at 5% (T5), 10% (T10), 15% (T15) and 20% (T20) levels.

Effect of different levels of incorporation of surimi powder: Fish protein powder (FPP) has a strong interaction with other proteins and possesses a high gelation ability. Due to this, it has been used in the food industry as a binder, dispersing agent and emulsifier in preparing herring roe, fillet blocks, and restructured products from beef, pork and chicken (Pires *et al.*, 2012). In texture profile analysis, the response of a sample to a compressive or tensile force is measured by means of time. Hardness refers to the force required for a sample to reach a certain degree of deformation (Yang *et al.*, 2018). Santana *et al.* (2018) reported that gelation properties are responsible for foods texture, particularly its breaking pattern. Yathavamoorthi *et al.* (2010) reported that springiness, gumminess, chewiness, fracture force, and cohesiveness is also important in terms of texture profile parameters. The hardness of fortified pasta in the present study was observed to show an increasing pattern from T0 to T20. Jalgaonkar *et al.* (2018), while analysing the effect of incorporation of DSF (Defatted soy flour) on the hardness of pasta showed an increase in hardness of pasta from 9.90 N (control) to 14.43 N (5% DSF). Furthermore, increase in the proportion of DSF from 5 to 25% resulted in a minor decrease in hardness from 14.43 to 13.07 N. According to Krishnan and Prabhasankar (2010), variation in the hardness of pasta with different ingredients could be due to variation in gluten strength due to substitution by non-gluten ingredients, which has happened in the present study as well. Fracturability encompasses crumbliness, crispiness, crunchiness, and brittleness. A material is brittle if it is liable to fracture when subjected to stress. That is, it has little tendency to deform (or strain) before fracture and usually makes a snapping sound. The fracturability was found to be highest in the T20 sample. Springiness indicates the rate at which a deformed material goes back to its initial form after the deforming force is removed (Civille and Szczesniak, 1973). There were no significant variations for springiness and cohesiveness among the samples. A gradual increase in gumminess and chewiness was observed with increase in fortification level of surimi powder. Gumminess can simulate the energy required to break the semi-solid sample into a stable state that can be swallowed (Yang *et al.*, 2018) while chewiness is the mouth feel the sensation of laboured mastication due to sustained, elastic resistance from the product, defined as the product of hardness × cohesiveness × springiness. There were no significant variations ($p>0.05$) in gumminess, chewiness and resilience among the fortified pasta samples studied.

Petitot *et al.* (2010) said that the colour parameter of pasta is an important factor responsible for consumer acceptance. Pongpichaiudom and Songsermpong (2018) observed that generally, consumers like pasta with a bright yellow colour. The L* value increased to 81.76±1.52 in sample T5 upon addition of 5% surimi powder, and further fortification with surimi powder resulted in a decreased lightness. No significant difference ($p>0.05$) in redness values (a*) was observed among the samples. The yellowness of raw pasta samples was detected to increase with the increase in fortification of pasta with surimi powder. Therefore, considering the preference of consumers with a bright yellow colour, it may be concluded that the fortification levels above 5% i.e., treatment T10 to T20 will be preferred more due to better yellowness than T0 and T5.

The ability of pasta to absorb water is influenced by the composition of raw material and processing conditions (Marti *et al*., 2011). WAI is considered as an important parameter for pasta. The water absorption index gradually decreased from T0 to T20. Similar results were found by Desai *et al.* (2018) for fortified pasta with 5–20 g/100 g Salmon fish powder (SFP). Addition of SFP caused a significant ($p<0.05$) decrease in water absorption index compared with control and water absorption value ranged from 103.47 g/100 g to 81.62 g/100 g for pasta containing 5–20 g/100 g SFP, respectively, and was 105.46 g/100 g for control. Desai *et al.* (2018) explained, this was due to the substitution of semolina flour with salmon powder in pasta samples, which reduces starch swelling and pasta water absorption by the formation of weak protein network through starch-lipid complex and competing with the starch for water. Therefore, in the present study, the highest WAI is for control pasta due to a higher amount of starch content. In fortified samples, tilapia surimi powder competed with starch causing a reduction in starch swelling and less water absorbed by pasta containing surimi powder. The results are in agreement with Bagdi *et al.* (2016) and Lorusso *et al.* (2017), who reported that pasta enriched with aleurone rich flour (protein 26.67% and fat 4.26%) and quinoa flour has significantly decreased WAI compared to wheat only pasta. T5 containing 5% surimi powder was observed to have the highest WAI among all fortified treatments.

According to Tudorica *et al.* (2002), optimal cooking time is the time necessary to obtain complete gelatinization of starch. Among the treated samples lowest OCT was observed in T10. Giuberti *et al.* (2015) opined that the optimal cooking time depends primarily on the rates of water penetration and starch gelatinization.

The swelling index gradually decreased from sample T0 to sample T20. Similar results were found by Desai *et al.* (2018) that swelling index decreased significantly ($p<0.05$) with the addition of salmon fish powder (SFP) in pasta samples. He also added that the reduced-swelling index could be due to the formation of a protein network and starch-lipid complex in the pasta enriched with salmon powder resulting in the limited supply of water for starch granules for swelling and gelatinization.

Therefore, it may be concluded that pasta can be fortified using surimi powder prepared from *O. mossambicus,* with increasing hardness and fracturability observed as fortification increased. The fortification levels above 5%, i.e., 10% in treatment T10 to 20% in treatment T20 will be preferred more due to better yellowness than T0 and T5. WAI was highest in sample T5 among fortified sample and the values decreased with increased levels of fortification. Optimal cooking time was lowest in sample T10, and the swelling index decreased in the fortified samples.

Conflict of interest: Authors have no conflict of interest in this study.

Author's contribution: AI: Involved in investigation, data generation, preparing original draft; SC: Engaged in conceptualization, data curation, supervision and final editing; SN, KCD, PM, AB: Involved in statistical analyses, methodology, checking and editing.

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