EFFECT OF THE ADDITION OF SMOKED TROUT FILLET POWDER TO THE QUALITY PROPERTIES OF PASTA

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ABSTRACT

In this study, quality properties of six pasta samples, prepared by substituting semolina with smoked trout fillet powder (STFP), were investigated. The addition of STFP to the pasta formulation resulted in an increase in protein, fat and ash content, energy value, antioxidant activity, phenolic content, optimum cooking time, cooking loss, and a* and b* values, but a decrease in carbohydrate content, water absorption capacity, swelling index and L* value. Furthermore, SEM images revealed that addition of STFP leads to an increase in protein matrix around the starch molecules, and its addition in quantities up to 15% showed acceptable sensory scores.

Keywords: pasta enrichment, pasta quality, smoked trout fillet powder

1. INTRODUCTION

Pasta is the most commonly consumed food product after bread among cereal products, and is traditionally produced from wheat semolina and water. The popularity of pasta is a result of its low cost, long shelf life, sensory characteristics and nutritional properties (FRADIQUE *et al*., 2013; KAUR *et al*., 2013; GOES *et al*., 2016). The Food and Drug Administration and the World Health Organization both recognize pasta as a good vehicle for enrichment with nutrients (BELEGGIA *et al*., 2011), and it is also known to be a rich source of complex carbohydrates and B vitamins, but as a poor source of protein and essential amino acids. This has led to many studies being carried out to enrich pasta with protein-rich ingredients such as meat, seafood (such as fishes and shrimp), legumes (such as chickpea, split pea, lentil, cowpea, mung bean and faba bean flour) (GALLEGOS-INFANTE *et al*., 2010; KADAM and PRABHASANKAR, 2012; LAKSHMI DEVI *et al*., 2013; LIU *et al*., 2016; PETITOT *et al*., 2010; SAVITA *et al*., 2013; WOJTOWICZ and MOSCICKI, 2014; WOOD, 2009; ZHAO *et al*., 2005). Such enrichments can have an effect on certain qualities of pasta, such as color, sensory characteristics, texture and cooking parameters (MERCIER *et al*., 2011).

Fish provide several nutritional benefits, such as high quality proteins that contain essential amino acids, and are a good source of lipids, complex B vitamins and such minerals as phosphorus, magnesium, zinc and iron (GOES *et al*., 2016). Fish is usually consumed in its fresh form, but can also be consumed after being dried, salted or smoked. Smoking techniques have been used as a preservation method for centuries. Besides affecting the characteristic color and flavor of food, smoking processes also has antimicrobial and antioxidative effects that are known to extend the shelf life of foods (LINGBECK *et al*., 2014).

Before marketing, smoked fish fillet is packed in standard weights. The edges of smoked fillets must be cut to meet a standard weight for packaging. These pieces that showed the same nutritional characteristics as the fish fillets, are discarded as production waste or are processed into low value-added products. Such waste can be used in the manufacture of enriched, high value-added food products.

The objective of this study is to investigate the chance of utilization of such fillet pieces and to examine the possibility of pasta nutritional value enhancement. It was also aimed to determine the changes in the cooking characteristics, antioxidant activity, microstructural properties, sensory properties and color attributes of pasta samples with the addition of smoked trout (*Oncorhynchus mykiss*) fillet powder (STFP).

2. MATERIAL AND METHODS

2.1. Raw materials

Smoked trout fillet pieces were dried in a cabinet dryer (Yucebas Machine Analytical Equipment Industry, Izmir, Turkey) at 50°C until <10% moisture content was achieved. The airflow rate in the cabinet dryer was 0.2 m/s and the relative humidity of the air was in a range of 19–21 %. After drying, the samples were ground into powder of a <1000 μm particle size, and the STFP was then stored at -18 °C until use.

Wheat semolina (particle size <450 μm), deionized water and common salt were used in the preparation of each pasta sample.

2.2. Pasta production

The STFP was added to the pasta formulation in quantities of 5, 10, 15, 20 and 25. The formulations of the pasta samples are shown in Table 1. The salt content of the STFP was found to be 6.3 %, and so the salt content was adjusted to 1.5 % in the pasta formulations.
The ingredients were mixed in the kneading vessel of the laboratory pasta machine (Dolly pasta machine, La Monferrina, Italy) at room temperature for 10 min to make the pasta dough, and the dough was then extruded using the pasta machine. A no. 28 die (6 mm wide, 0.85 mm thick, PTFE) was used to shape the dough, which was then cut into 10 cm lengths. The pasta samples were dried at room temperature until a <10% moisture content was reached (~20 h).

Table 1. Formulations of pasta samples.

Ingredients	STFP Inclusion Level					
	0%	5%	10%	15%	20%	25%
Wheat Semolina (g)	100	95	90	85	80	75
STFP (g)	0	5	10	15	20	25
Deionized Water (mL)	34	34	36	39	39	41
Salt (g)	1.5	1.2	0.9	0.5	0.2	0

The control sample (unenriched) and the enriched pasta samples were packaged in a moisture-proof material (PET+COEX PA) and stored at room temperature for further analyses.

2.3. Proximate composition analysis

The crude protein content of the samples was determined using the Dumas method (SHEA and WATTS, 1939) with a Dumatherm analyzer (Gerhardt GmbH & Co. KG, Königswinter, Germany), while fat content, moisture content and ash content were measured using AOAC (1990) methods. Carbohydrate content was estimated by subtracting the moisture, protein, fat and ash content from 100% Energy values were calculated using the following equation (SOUCI *et al.*, 2000);

$$Energy\ value(kcal/g) = (Carbohydrates \times 4) + (Proteins \times 4) + (Lipids \times 9)$$

2.4. Total phenolic content and total antioxidant activity of pasta

For the extraction of phenolics, 10 mL of aqueous methanol (70:30 v/v) was added to 1 g of the samples. After 10 min of sonication in an ultrasonic bath (E 60 H Model, Elma Co., Germany), the mixture was shaken in a mechanical shaker (WiseShake SHO-1D, Wertheim, Germany) for 15 min at room temperature. At the end of the centrifugation (NF 1200 R, Nuve, Turkey) of mixture at 8500 g at 4°C for 20 min, supernatants were collected. The total phenolic content and antioxidant activity of the extracts were analyzed in duplicate.
Total phenolic content (TPC) analyses were carried out by the method of SINGLETON *et al*. (1998), in which 1 mL of extract is poured into a test tube, after which, 5 mL of 10-fold

diluted Folin-Ciocalteu and 4 mL of Na_2CO_3 (7.5%) solutions were added. After 2 h incubation in the dark, the absorbance of the mixtures was measured at 760 nm against a reagent blank and standards using a spectrophotometer (PG-80 UV-Vis Spectrometer, PG Instruments, United Kingdom). The results were expressed as milligrams gallic acid equivalent (GAE)/100 g wet basis.
Total antioxidant activity (TAA) was measured using the 2.2-Diphenyl-1-picrylhydrazyl (DPPH) method according to THAIPONG, *et al.* (2006). Twenty four mg of DPPH was dissolved in 100 mL of methanol for prepared as a stock solution and then stored at -20 °C until use. The working DPPH solution was prepared by mixing the stock solution with methanol to obtain an absorbance value of 1.1±0.02 at 515 nm. The extracts (150μL) were allowed to react with the working solution (2850 μL) for 24 h in the dark, after which the absorbance of the samples was measured at 515nm. The standard calibration curve was linear between 25 and 800 μM Trolox, and the results were expressed in μmol Trolox equivalent (TE)/100 g wet basis.

2.5. Pasta cooking tests

2.5.1 Optimum Cooking Time

The optimum cooking time (OCT) of the samples was determined according to AACC (2000). Briefly, 25 g of pasta was broken into 5 cm constant lengths and added into 300 mL of boiling distilled water. Every 30 seconds, a piece of pasta was taken out and squeezed between two glass plates. The OCT was defined as the time taken until the white center of the sample disappeared.

2.5.2 Cooking loss

For the determination of cooking loss, 10 g of pasta was cooked for the OCT, after which the sample was rinsed with distilled water in a Buhner funnel. Cooking loss was measured by evaporating the cooking water and rinsing with water in a hot air oven at 105 °C. The residue was weighed and reported as a percentage of the uncooked pasta sample (TUDORICA *et al.*, 2002).

2.5.3 Water absorption capacity

After cooking the 10 g pasta samples at OCT, the water absorption capacity (WAC) was calculated using the following equation (MARTI *et al.*, 2013):

$$WAC(\%) = \frac{Weight\ of\ cooked\ pasta - Weight\ of\ uncooked\ pasta}{Weight\ of\ uncooked\ pasta} \times 100$$

2.5.4 Swelling index

The swelling index (SI) of the samples was determined according to the CLEARY and BRENNAN (2006). Twenty-five g of pasta was cooked in 250 mL of boiling distilled water for OCT, and then dried at 105°C. The SI was expressed as:

$$SI = \frac{Weight\ of\ cooked\ pasta - Weight\ of\ dried\ pasta}{Weight\ of\ dried\ pasta}$$

2.6. Microstructure of raw pasta

The pasta samples were freeze-dried (Thermo Savant ModulyoD-230, USA) for 8 h, and the freeze-dried samples were coated with gold. The microstructure of the surface of the raw pasta samples was visualized with scanning electron microscopy (SEM) (FEI Quanta 250 FEG, USA).

2.7. Color measurement

The surface color values of the cooked pasta were measured using a Hunter Lab Miniscan XE Colorimeter (Hunter Associates Laboratory, Reston, VA). L*, a* and b* parameters were recorded, and the changes in color resulting from the addition STFP to the pasta formulation were determined according to a color differential index (ΔE) that calculated the following equation;

$$\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$$

Where:
ΔL* was calculated as L* sample-L*control;
Δa was calculated as a* sample-a* control;
Δb was calculated as b*sample-b*control

According to the Handbook of Colour Science (YAMAUCHI, 1989), ΔE values describe visual color differences as follows: (0–0.5, trace difference); (0.5–1.5, slightly discernible; hard to detect with the human eye); (1.5–3.0, noticeable; detectable by trained people); (3.0-6.0, appreciable; detectable by ordinary people); (6.0–12.0, large; large difference in the same color group); (Larger than 12; extreme; another color group).

2.8. Sensory evaluation

The pasta samples were cooked (100 g of pasta in 1 L of boiling water with 10 g salt) for OCT and drained. Pasta samples were presented individually on plastic trays to each panelist. The sensory evaluation was made by 44 panelists from Pamukkale University, Department of Food Engineering (29 females, 15 males; age range 20–50). The panelists scored each sample for color, odor, taste, texture and overall acceptability on a hedonic scale ranging from 1 (dislike extremely) to 7 (like extremely). The samples were labeled with randomly selected three-digit numerical codes. Bread and water were given to the panelists for rinse their palates between samples. The final scores were calculated from the average of the 44 scores (AYDIN and GOCMEN, 2011; CARDENAS-HERNANDEZ *et al*., 2016).

2.9. Statistical analysis

All experiments were performed in duplicate. Statistical analyses were made using SPSS 22.0 (IBM SPSS Inc., Chicago, IL, USA) software. A Duncan's multiple range test was used and the levels were considered significantly different at $p<0.05$.

3. RESULTS AND DISCUSSION

3.1. Raw materials

The moisture, protein, fat, ash and carbohydrate content, and the energy value, TAA, TPC and color values of wheat semolina and STFP are shown in Table 2.

Table 2. Nutritional and Chemical Properties of wheat semolina and STFP.

	Wheat semolina	STFP
Moisture (%)	13.41±0.07	7.61±0.45
Protein (%)	10.91±0.02	72.49±0.82
Fat (%)	1.79±0.37	14.29±0.74
Ash (%)	0.90±0.03	5.03±0.22
Carbohydrate (%)	73.00±0.40	0.59±0.31
Energy Value (kcal/100g)	351.69±1.71	420.92±4.57
Total Antioxidant Activity (μmol TE/100g)	2.20±0.10	10.06±0.39
Total Phenolic Content (mg GAE/100g)	33.30±0.46	51.22±0.91
Hunter color values		
L*	85.61±0.08	53.33±1.06
a*	0.04±0.03	6.27±0.18
b*	18.45±0.08	27.40±0.52

STFP: Smoked Trout Fillet Powder.

The moisture value of semolina was determined under the maximum limit (14.5%) of the Turkish Food Codex (2002). In addition, the protein content of semolina was detected above the minimum protein content (10.5%) defined in the Turkish Food Codex (2002). The results reveal that while STFP is a remarkable source of protein and fat, semolina is a good source of carbohydrate. It was determined that the use of fish powder in pasta production enhances the nutritional quality of enriched pasta. Additionally, the energy values of semolina and STFP were determined as 351.69 kcal/100g and 420.92 kcal/100g, respectively. STFP has a higher energy value than semolina due to its high protein and fat content. Furthermore, STFP demonstrates higher total antioxidant activity and total phenolic content than wheat semolina. The high level of antioxidant activity in the STFP can be attributed to the applied smoking process, in that smoke contains various phenolic compounds (GOULAS and KONTOMINAS, 2005; KJALLSTRAND and PETERSSON, 2001). The color measurement indicated that STFP has higher a* and b* values and lower L* values than wheat semolina.

3.2. Proximate composition of samples

The proximate composition of the control sample and the enriched samples are presented in Table 3.

Moisture content was increased after the addition of STFP, although all results were found to be under the critical moisture value of 13% identified in Turkish Standard 1620 (2017). The STFP may have increased the moisture content of the samples due to the water holding capacity of STFP proteins during dough preparation (CHIN *et al*., 2012; ZAYAS, 1997).

Table 3. Proximate composition of samples.

Sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Carbohydrate (%)	Energy Value (kcal/100g)
Control	9.44±0.15^{b}	13.87±0.28^{d}	1.70±0.19^{d}	1.33±0.03^{b}	73.66±0.59^{a}	365.39±0.47^{c}
STFP 5%	10.12±0.06^{ab}	14.29±0.21^{d}	3.61±0.73^{cd}	1.39±0.17^{b}	70.59±0.41^{a}	371.96±4.08^{bc}
STFP 10%	10.32±0.26^{a}	17.97±0.18^{cd}	5.52±0.71^{bc}	1.45±0.20^{b}	64.74±0.96^{b}	380.51±3.27^{ab}
STFP 15%	10.06±0.55^{ab}	19.72±2.40^{bc}	5.79±1.54^{ab}	1.56±0.08^{b}	62.87±4.41^{bc}	382.48±5.84^{ab}
STFP 20%	10.15±0.18^{ab}	23.27±2.93^{ab}	7.22±0.42^{ab}	2.20±0.04^{a}	57.16±2.73^{cd}	386.69±3.00^{a}
STFP 25%	10.44±0.45^{a}	25.76±2.51^{a}	7.88±0.88^{a}	2.29±0.11^{a}	53.63±2.19^{d}	388.40±6.66^{a}

STFP: Smoked Trout Fillet Powder.
Different superscript letters in columns indicate statistical differences ($p<0.05$).

The protein, fat and ash content of the samples increased with the addition of STFP. In particular, the protein content of the sample with the addition of 25% STFP was detected to be 1.9 times higher than the control sample due to the high protein content (72.49%) of STFP. The fat content of the control sample and 25% STFP-added sample were detected as 1.70% and 7.88% respectively. The control sample was significantly lower than the 10, 15, 20 and, 25 % STFP-added samples ($p<0.05$). The ash content analysis revealed 1.33% ash content for the control sample and 2.29% for the 25% STFP-added sample. The ash content of the 25% and 20% STFP added samples were significantly higher than the rest of the groups ($p<0.05$). The statistical analysis revealed that the control and STFP 5% samples were similar in this respect ($p>0.05$).
The carbohydrate ratio decreased significantly with the addition of STFP, while the energy value increased ($p<0.05$). Although the energy value was higher, it was not regarded as a negative outcome due to the higher fat and protein contents of the enriched samples.
The results of the present study concur with those of LIU *et al*. (2016) and CHIN *et al*. (2012).

3.3. Total phenolic content and antioxidant activity

Traditionally, meat, fish and some other foods are subjected to smoking not only to give them a special taste, color and odor, but also to improve shelf life, based on the antioxidant and antibacterial properties of smoke (SEMANOVA *et al*., 2016; SOARES *et al*., 2016).
The TAA and TPC of the samples are shown in Table 4.

Table 4. Total antioxidant activity and phenolic content of samples

Sample	Total Antioxidant Activity (μM TE/100g)	Total Phenolic Content (mg GAE/100g)
Control	1.79±0.29^{b}	35.93±1.75^{c}
STFP 5%	4.75±0.88^{a}	36.36±1.90^{bc}
STFP 10%	4.76±0.92^{a}	38.77±2.24^{abc}
STFP 15%	4.99±0.76^{a}	38.83±0.99^{abc}
STFP 20%	5.10±1.11^{a}	40.92±2.43^{ab}
STFP 25%	5.12±0.41^{a}	42.21±0.30^{a}

STFP: Smoked Trout Fillet Powder.
Different superscript letters in columns indicate statistical differences ($p<0.05$).

TAA and TPC were both detected in higher values in the STFP than in the semolina (Table 2). So enriched samples had higher TAA and TPC values than the control samples. The TAA values of the samples ranged between 1.79 µM TE/100g and 5.12 µM TE/100g. The TAA of the control sample was significantly lower than STFP-added samples ($p<0.05$).
The TPC of the samples increased significantly with the addition of STFP to the pasta formulation ($p<0.05$), and it was determined that the TPC of the 25% STFP-added sample was 1.2 times higher than the control sample.
Previous studies have investigated the effects of smoking processes on certain foods, and similar results have been found. SHAIBAN *et al*. (2006) investigated the effect of different types of woods used for smoking cheese, and found that smoked cheese showed higher total phenolic content and total antioxidant activity than non-smoked cheese. SEROT *et al*. (2004) investigated 10 major phenolic compounds in herring fillets smoked using different methods, and found that the sum of the content of 10 phenolic compounds in smoked fillets was strongly affected by the method used.

3.4. Pasta cooking tests

Cooking characteristics are a strong indicator of pasta quality. The cooking characteristics of the pasta samples are shown in Table 5. OCT ranged from 9.50 to 11.00 minutes, and compared to the control sample, the OCT showed an increasing trend with the addition of STFP. Higher optimum cooking times have also been reported in meat-based pasta. KADAM and PRABHASANKAR (2012) reported that cooking time increased from 8.5 min (control sample) to 14.0 min with the addition of 30% shrimp meat. Cooking time is related to the starch gelatinization and water penetration rate. Water enter into the starch granule may be restricted by more complex protein networks, which may cause a delay in the start of the gelatinization process (LIU *et al*., 2016).
The swelling index of pasta is an indicator of the water absorbed by the proteins during cooking (GOPALAKRISHNAN *et al*., 2011). Increasing the STFP ratio in the formulation caused the water absorption capacity and swelling index to decrease significantly ($p<0.05$), which could be related to the lower water absorption capacity of the protein network in STFP than in the gluten network. Previous studies into bran-enriched and fish powder-enriched pasta have reported similar decreases in water absorption capacity and swelling index (ARAVIND *et al*., 2012; DESAI *et al*., 2018; GATTA *et al*., 2017). PETITOT *et al*. (2010) determined that pasta samples made with split pea flour and faba bean flour had lower water absorption capacities than the control samples. In contrast, BASKARAN *et al*. (2011) reported that pasta enriched with skimmed milk powder and whey protein concentrate had higher swelling index values than the control sample.

Table 5. Cooking characteristics of the control and STFP-enriched pastas.

Sample	Optimum Cooking Time (Min)	Water Absorption Capacity (%)	Cooking Loss (%)	Swelling Index
Control	$9.50±0.01^{d}$	$208.32±1.62^{a}$	$5.87±0.04^{b}$	$2.74±0.03^{a}$
STFP 5%	$9.75±0.35^{cd}$	$204.76±3.21^{ab}$	$7.50±0.01^{a}$	$2.72±0.05^{a}$
STFP 10%	$10.00±0.01^{bcd}$	$197.48±5.08^{bc}$	$7.57±0.23^{a}$	$2.62±0.07^{ab}$
STFP 15%	$10.50±0.71^{abc}$	$197.80±2.84^{bc}$	$7.82±0.69^{a}$	$2.63±0.01^{ab}$
STFP 20%	$10.75±0.35^{ab}$	$190.20±1.65^{cd}$	$8.15±0.50^{a}$	$2.55±0.04^{b}$
STFP 25%	$11.00±0.01^{a}$	$182.85±2.53^{d}$	$8.42±0.15^{a}$	$2.51±0.08^{b}$

STFP: Smoked Trout Fillet Powder.
Different superscript letters in columns indicate statistical differences ($p<0.05$).

Cooking loss is defined as the amount of solids lost into the cooking water of a sample cooked for OCT (SOZER *et al*., 2007). An analysis identified statistically similar levels of cooking loss in the enriched samples ($p>0.05$), while the control sample was significantly different ($p<0.05$). Increasing the STFP ratio in the pasta formulation increases the level of cooking loss of the samples. The cooking loss values of the samples ranged between 5.87% and 8.42% all of which fall under the acceptable limit of 9% (AACC, 2000). An increase in the proportion of STFP in the formulation results in a decrease in the amount of semolina-based components, such as gluten, in pasta, which leads to a weakening of the gluten network. Similarly, some studies on the enrichment of pasta with various ingredients have also shown an increase in the level of cooking loss (ARAVIND *et al*., 2012; GALLEGOS-INFANTE *et al*., 2010; ISLAS-RUBIO *et al*., 2014; SANT'ANNA *et al*., 2014). The supplementation of different non-gluten flours in pasta formulation has been reported to dilute the gluten strength and weaken the pasta structure, which may increase the level of dry matter lost into the cooking water (GALLEGOS-INFANTE *et al*., 2010). In addition, it was stated that pasta had low cooking loss when dried at high temperature. PASQUALONE *et al*. (2016) reported that when a high-temperature drying program was adopted, cooking losses were ranged from 3.2 to 4.8 % in control pasta and in pasta samples enriched of lyophilized tomato matrix or with durum wheat bran extracts produced by supercritical carbon dioxide or ultrasound.

3.5. Microstructure of raw samples

SEM images demonstrate the arrangement of the gluten network and starch in pasta (RAJESWARI *et al*., 2013). The surface microstructure of raw pasta samples is illustrated in Fig 1. Images of the control pasta sample show numerous starch granules that appear to vary in both size and shape (Fig. 1a). The outer surface of the pasta appears to be coated with a thin protein film (Fig. 1a), which has also been reported in previous studies (PASQUALONE *et al*., 2016; ALIREZA SADEGHI and BHAGYA, 2008; CUNIN *et al*., 1995).

As dried pasta has a very limited water system, the starch and protein compete strongly for water during cooking. The less protein surrounding the starch granules, causes the faster starch swelling and gelatinization. (DE NONI and PAGANI, 2010).With the addition of STFP to the pasta formulation, the protein matrix around the starch molecules enhances, and the starch molecules are coated with a thicker protein network by the increase of STFP addition ratio (Fig. 1b, 1c, 1d, 1e, 1f)., as also observed by ALIREZA SADEGHI and BHAGYA, (2008) and LIU *et al*., (2016).This phenomenon also explained the extension of cooking time by the increasing addition ratio of STFP.

3.6. Color measurement

The color of pasta is very important quality parameter in terms of consumer preferences (CARINI *et al*., 2009). The color parameters of the enriched and control samples are shown in Table 6. It can be noted that the L* value (lightness) decreases with the increasing supplementation levels of STFP. The L* values of the control and the 5% STFP-added sample were statically similar ($p>0.05$), and significantly higher than the other enriched samples ($p<0.05$). Pasta samples enriched with STFP had a significantly higher a*(redness) and b*(yellowness) values than the control sample ($p<0.05$). Overall, the color values indicate that enriched samples have more redness (a*) and more yellowness (b*), but less lightness (L*) values than the control sample. The changes in color were found to be related to the original color of the STFP and the semolina (Table 2).

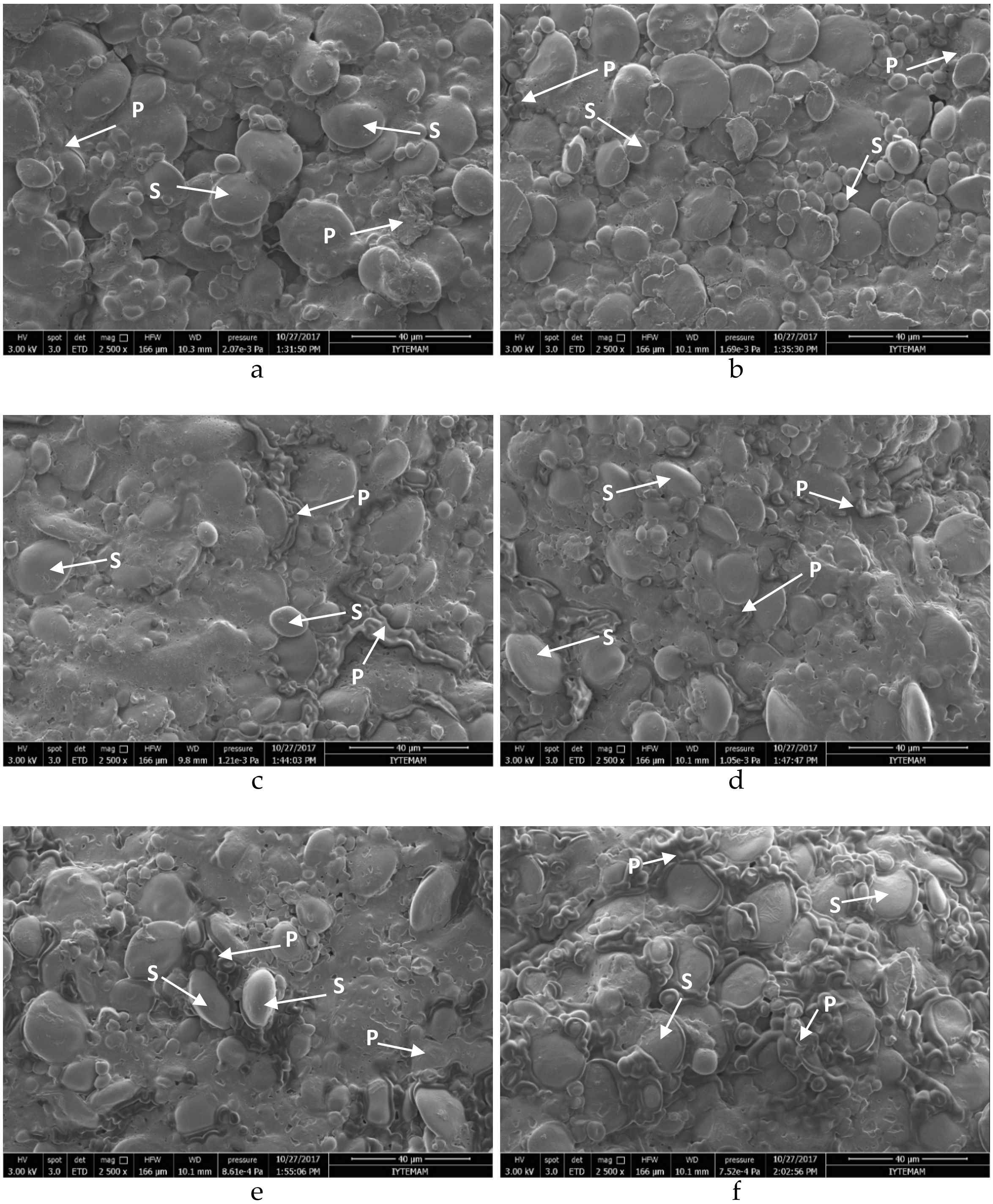

Figure 1. Surface SEM images of (a) control pasta, (b) 5% STFP pasta, (c) 10% STFP pasta, (d) 15% STFP pasta, (e) 20% STFP pasta, (f) 25 % STFP pasta. S: starch granules, P: protein network. Magnification 2500x.

These results were in close agreement with KADAM and PRABHASANKAR (2012), AYDIN and GOCMEN (2011), ALIREZA SADEGHI and BHAGYA (2008), who reported that samples supplemented with oat flour, shrimp meat and mustard protein isolate had lower L values and higher a and b values than the control sample due to the darker color of the enrichment materials than semolina.

The color differential index (ΔE) was indicated the color changes between the control sample and the enriched samples. The ΔE values of the samples was increased with the addition of STFP to the pasta formulation. According to the Handbook of Colour Science, 10%, 15% and, 20% STFP-added samples can be classified as "large difference in the same color group", while the classification of the 5% STFP-added sample and the 25% STFP-added sample were "appreciable; detectable by ordinary people" and "extreme, another color" respectively. DESAI *et al*., (2018) reported that the incorporation of fish powder into pasta increased ΔE values, while KHAN *et al*. (2014) investigated the color changes in sorghum flour-enriched pasta, stating that all the ΔE values of the cooked enriched samples were greater than 12, being classified as "extreme, another color" by YAMAUCHI (1989) in the Handbook of Colour Science.

Table 6. Color parameters of cooked pasta samples.

Sample	L*	a*	b*	ΔE
Control	68.01±0.45^{a}	-3.06±0.02^{f}	14.81±1.10^{e}	
STFP 5%	67.00±0,34^{a}	-2.30±0.10^{e}	18.63±0.01^{d}	4.04±1.05^{d}
STFP 10%	65.79±0.47^{b}	-1.55±0.10^{d}	20.62±0.33^{c}	6.40±0.66^{c}
STFP 15%	64.49±0.52^{c}	-0.42±0.27^{c}	22.76±0.64^{b}	9.09±0.30^{b}
STFP 20%	62.84±0.59^{d}	0.45±0.13^{b}	24.26±0.95^{ab}	11.32±0.01^{a}
STFP 25%	61.87±0.35^{d}	1.24±0.11^{a}	25.25±0.66^{a}	12.85±0.45^{a}

STFP: Smoked Trout Fillet Powder.
Different superscript letters in columns indicate statistical differences ($p<0.05$).

3.7. Sensory Evaluation

The sensory properties of the samples were evaluated based on color, odor, taste, texture and overall acceptability, and the results are shown in Table 7. The control sample and the 5% STFP-enriched samples were found to be statistically similar in all parameters ($p>0.05$).

Table 7. Sensory properties of control and smoked trout fillet powder enriched pastas.

Sample	Color	Odor	Taste	Texture	Overall Acceptability
Control	4.84±0.21^{a}	4.86±0.22^{a}	4.78±0.34^{a}	5.01±0.31^{a}	4.90±0.25^{a}
STFP 5%	4.98±0.03^{a}	4.88±0.23^{a}	4.77±0.27^{a}	5.00±0.11^{a}	4.86±0.26^{a}
STFP 10%	4.75±0.11^{a}	4.50±0.06^{b}	4.36±0.21^{ab}	4.34±0.23^{ab}	4.38±0.23^{ab}
STFP 15%	4.84±0.18^{a}	4.17±0.01^{c}	3.94±0.33^{bc}	4.25±0.41^{ab}	4.00±0.30^{bc}
STFP 20%	4.77±0.08^{a}	4.19±0.03^{c}	3.46±0.18^{c}	3.84±0.23^{b}	3.63±0.12^{c}
STFP 25%	4.48±0.44^{a}	3.90±0.03^{d}	3.48±0.08^{c}	3.73±0.57^{b}	3.56±0.33^{c}

STFP: Smoked Trout Fillet Powder.
Different superscript letters in columns indicate statistical differences ($p<0.05$).

No difference was identified between the color values of all samples ($p>0.05$), while odor and taste values decreased significantly with the addition of STFP ($p<0.05$). Some of the panelists reported an excessive fish odor and taste in the 20% and 25% STFP-added samples, and a decrease in texture values was detected with STFP supplementation. During cooking, it was observed that especially the 20% and 25% STFP-added pastas had a tendency to rupture, and the panelists also pointed out that these pastas were very easily ruptured. The addition of STFP, which causes gluten reduction and a weakening of the gluten network, might reduce the resistance of the pasta. It was determined that the overall acceptability values of all the samples scored above 3.5, which the midpoint in a 7-point hedonic scale.

This study follows on from the research by CHIN *et al*. (2012), who reported that the color, taste and overall acceptability scores of noodles decreased with the addition of surimi powder.

On the other hand KADAM and PRABHASANKAR (2012), when supplementing pasta with shrimp meat, found from a sensory analyses that the addition of 20% shrimp meat had the best result in the overall score. LIU *et al*. (2016) enriched pasta with beef emulsion, and the overall preference scores showed that a 30% beef emulsion-added sample was statically similar to a commercial pasta sample.

4. CONCLUSIONS

The consumption of fish is known to have many benefits to human health. It can be added to various foods as a good source of enrichment, due mainly to its high protein content. Fish meat is considered to be a good source of enrichment for pasta. In the present study, it was determined that the addition of STFP increased the nutritional value of pasta, and also increased the antioxidant activity and phenolic content. The cooking analysis showed that the addition of STFP increased OCT and cooking loss, and decreased WAC and swelling index. As can be observed from the SEM images, the addition of STFP to the pasta formulation leads to an increased protein matrix around the starch molecules. An increased L* value, and decreased a* and b* values have been found in the enriched-STFP samples due to the darker color of STFP than semolina. The sensory analysis revealed overall acceptability scores of all samples above 3.5, although the 20% and 25% STFP-added samples were reported by the panelists to have an excessive taste and odor of fish. The 20% and 25% STFP-added samples were also noted to rupture during cooking. It was determined that the addition of 15% STFP enhanced the nutritional value of pasta, and also had acceptable cooking quality and sensory characteristics. Therefore, it can be concluded that fish pieces (production waste material) can be thought as pasta enrichment ingredients in case they are used in the mentioned concentration.

ACKNOWLEDGEMENTS

This work was funded by Pamukkale University, Unit of Scientific Research Projects, Turkey (Project No: 2014FBE052).

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Paper Received May 11, 2018 Accepted August 29, 2018