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Potential Use of Dried Trout Flesh Powder in Salty Biscuit Production

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ABSTRACT

Malnutrition in children is a current global concern. Biscuit, prepared with a variety of cereals, is a delicious snack for children; however, its protein content may be low. Therefore, developing healthier biscuits with an increased protein content is of great interest to biscuit manufacturers. In this study, dried (Rainbow) trout flesh powder was utilized as a protein source in biscuit formulation. Salty biscuits were prepared by the substitution of wheat flour with dried trout flesh powder at a level of 0, 5, 10 and 15% and evaluated in terms of their physical, chemical and sensory properties. Biscuit weight and thickness decreased, spread ratio increased with dried trout flesh powder substitution. Spread ratio ranged between 14.20 and 14.58% in dried trout flesh powder substituted biscuits whereas it was 13.03% in control biscuit. Ash and protein content of the biscuits increased in the range of 11.46–25.69% and 28.05–84.58%, respectively. Carbohydrate content of biscuits decreased up to 12.86% by 15% dried trout flesh powder substitution. Salty biscuits with increased protein (8.72–12.57%) and ash content (3.21–3.62%), as well as decreased carbohydrates (62.90–68.90%) in comparison to control biscuit (6.81, 2.88 and 72.19%, respectively) were maintained. Breaking strength also decreased in 10 and 15% dried trout flesh powder substituted biscuits. Sensorial analysis showed that 10 and 15% dried trout flesh powder substituted biscuits were more appreciated by the panelists. In conclusion, the incorporation of 10 and 15% dried trout flesh powder into biscuit formulation could provide salty biscuits with increased protein content, improved textural properties, acceptable sensory attributes and could contribute to solving problems of post harvest fish losses as well as children's malnutrition.

Keywords: Trout, Flesh powder, Enrichment, Biscuit, Sensory properties

Tuzlu Bisküvi Üretiminde Kurutulmuş Alabalık Eti Tozu Kullanımı

ÖZ

Çocuklarda yetersiz beslenme mevcut küresel bir sorundur. Tahıllardan hazırlanan bisküvi, çocuklar için lezzetli bir atıştırmalıktır. Bununla birlikte, protein içeriği düşüktür. Bu nedenle, artan protein içeriğine sahip daha sağlıklı bisküviler geliştirmek araştırmacılar ve üreticiler için büyük önem taşımaktadır. Bu çalışmada, kurutulmuş alabalık eti tozu bisküvi formulasyonunda protein kaynağı olarak kullanılmıştır. Tuzlu bisküviler, buğday ununun kurutulmuş alabalık eti tozu (%0, 5, 10 ve 15) ile ikame edilmesiyle hazırlanmış ve fiziksel, kimyasal ve duyusal özellikler açısından değerlendirilmiştir. Alabalık eti tozu ikamesi ile bisküvi ağırlığı ve kalınlığı azalmış, yayılma oranı artmıştır. Alabalık eti tozu ikameli bisküvilerde yayılma oranı %14.20–14.58 arasında değişirken, kontrol bisküvisinde %13.03'tür. Bisküvilerin kül ve protein içeriği sırasıyla %11.46–25.69 ve %28.05 – 84.58 aralığında artmıştır. %15 kurutulmuş alabalık eti tozu ikame edilen tuzlu bisküvilerde karbonhidrat içeriği %12.86'ya kadar azalmıştır. Alabalık eti tozu içeren bisküvilerin protein içeriği %8.72–12.57, kül içeriği %3.21–3.62, karbonhidrat içeriği %62.90–68.90 arasında değişmekte olup kontrol bisküvisine kıyasla (sırasıyla %6.81, %2.88, %72.19) kül ve protein oranı yüksek karbonhidrat oranı düşük bisküviler elde edilmiştir. %10 ve %15 alabalık eti tozu ikameli bisküvilerin kırılma mukavemeti azalmıştır. Duyusal analizler, %10 ve %15 alabalık eti tozu ikameli bisküvilerin panelistler tarafından daha fazla beğenildiğini göstermiştir. Sonuç olarak, %10 ve %15 kurutulmuş alabalık eti tozunun dahil edilmesi, artan protein, gelişen tekstürel özellikler ve kabul edilebilir duyusal özelliklere sahip tuzlu bisküviler sağlayabilir ve avlama sonrası balık kayıpları ve çocukların yetersiz beslenme problemlerinin çözülmesine katkıda bulunabilir.

Anahtar Kelimeler: Alabalık, Et tozu, Zenginleştirme, Bisküvi, Duyusal özellikler

INTRODUCTION

Seafood is one of the most valuable foods in terms of its nutritional components due to its high protein content and presence of most of the amino acids. It is valuable due to high vitamin content and biological value [1]. As well known, three sides of Turkey is covered with seas. In Turkey, almost all of the fish obtained by fishing or aquaculture are consumed fresh, followed by frozen and processed products (canned, smoked, marinated, dried etc.) [2]. However, most of the fish obtained in the world is offered for consumption after processing. So, their shelf life is increased and product variety is provided by presenting products in different tastes and flavors to the market [3]. Despite this fact, throughout the world, post-harvest fish losses are of major concern; an estimated 27% of landed fish is lost or wasted between landing and consumption [4]. Therefore, evaluating fish by processing and incorporating into foods is of great importance.

Rainbow trout *(Oncorhynchus mykiss)* is an important fresh water fish in Turkey. Chemical composition of *Oncorhynchus mykiss* was reported between 16.45 – 20.7% protein, 1.2 – 10.8% fat and 1.29 – 1.80% ash in different studies [1,5-7]. Fish powder is a fish product with concentrated protein content [8]. It is a superior dietary supplement and can be utilized to fortify a diversity of cereal products to provide a healthy source of easily digestible proteins [9]. When dried, its high protein content make fish an excellent source of protein in food formulations. So, small quantities of dried fish enables a remarkable increase in protein content of the product.

Malnutrition in children is a current global concern. Biscuits, prepared from cereals, are delicious snacks for children. However, their protein content is low. Therefore, developing healthier biscuits with increased protein content is of great interest to researchers and manufacturers. Many children do not prefer to consume fish and fishery products directly. So, they do not benefit from a healthier diet, if these products are not incorporated in children’s favorite food, such as biscuits [9].

Most of bakery products are used as a source for incorporation of different nutritionally rich ingredients for their diversification [10]. Biscuits are among the most popular bakery items mainly due to their ready to eat nature, good nutritional quality, and availability in different varieties and affordable cost [11]. In addition, its consumption is increasing day by day due to the fact that it can be stored for long periods without staling and can be presented to the consumer in various content [12].

There are many researches investigating the effect of different fish species on food product quality and nutritional value. Some researchers investigated utilization of fish in pasta and noodle [13-16], bread [17], extruded snack [18,19], cereal bars [20], fish crackers [21-25] and fish chips [26] production. Other studies include enrichment of soups and pasta sauces [27] and tarhana [28]. Several studies have been conducted to incorporate fish powder or meal [9, 29, 30] and fish protein concentrates [31-33]. It is reported by many researchers [9,29, 31-33] that supplementation with fish flesh powder did not affect sensory properties of biscuits adversely, while increasing protein content.

Although there are several studies investigating the effect of various fish powder and protein concentrates on nutritional value and quality of many cereal based products, there is no published report on utilization of trout flesh powder in biscuit production. Considering the high protein content and acceptable sensory properties of fish powders and end products, post harvest losses, children’s malnutrition and the need for enriched biscuits in the market, the current study was carried out to produce salty biscuits by partial substitution of wheat flour with dried trout flesh powder (0%, 5%, 10% and 15%). Salty biscuits were evaluated for their physical, chemical and sensory properties.

MATERIALS AND METHODS

Materials

Rainbow trout *(Oncorhynchus mykiss)* used for enrichment of salty biscuits were obtained from a fish market in Manisa, Turkey. Wheat flour (13.80% moisture,10.65% protein, 0.62% ash) thyme, salt and milk powder (3.11% moisture, 26.24% protein, 27.10% fat, 5.76% ash) used as biscuit raw materials were supplied from a local market in Manisa. Shortening was obtained from Besler A.Ş (İstanbul, Turkey).

Methods

Production of Dried Trout Flesh Powder (DTFP)

Rainbow trout was immediately brought to Manisa Celal Bayar University laboratories for processing. They were washed under running tap water, deheaded and gutted carefully. Then, they were filleted, skin was removed, washed again, cut into small pieces and kept in the freezer (Beko, Turkey) at -40ºC for one week. Then, fish were freeze dried in a lyophilizer (Christ Alpha 2-4 LD+, Germany). Freeze drying took place in two stages; 24 hours sublimation and 24 hours desorption. Following the drying process, dried trout flesh were milled using a blade grinder (Retsch GM 200, Germany) for 80 seconds at 7500 rpm. The composition of the produced

DTFP was determined as 7.02% moisture, 77.71% protein, 7.09% ash and 8.05% oil. DTFP less than 500 micrometers was used in biscuit production. DTFP was stored in glass jars with lids until use in production.

Biscuit Formulation and Production

Formulations of control and DTFP substituted salty biscuits were given in Table 1. Biscuit production was carried out according to AACC Method 10.31.03 [34]. In the preliminary studies, thyme was an effective spice for both providing aroma and covering fish odor. Therefore, control biscuits were aromatized with thyme. DTFP substituted to wheat flour in the range of 0-15%. Dough mixing speed and durations in the method were modified as follows: All the dry ingredients were mixed in the 4th speed rate (90 rpm) of KitchenAid Mixer (5KSM150PS, KitchenAid, St. Joseph, Mich., USA) for 40 sec. After adding shortening, the mixture was mixed for 4 minutes at 6th speed rate (120 rpm). Milk powder solution (10% w/v) was added and the dough was mixed continously for 1.5 minutes more. Biscuit dough was then sheeted at a constant thickness through pasta press and baked at 220±5°C in convectional oven (Inoksan, Turkey) for 6 minutes.

Table 1. Biscuit formulations

Ingredients	Control biscuit	5% DTFP	10% DTFP	15% DTFP
Wheat Flour (g)	228.0	216.6	205.2	193.8
DTFP(g)	-	11.4	22.8	34.2
Shortening (g)	40.0	40.0	40.0	40.0
Milk powder solution (g)	135.0	135.0	135.0	135.0
NaCl (g)	4.5	4.5	4.5	4.5
$NaHCO_3$ (g)	3.4	3.4	3.4	3.4
$Ca(H_2PO_4)_2$ (g)	3.8	3.8	3.8	3.8
Tyhme (g)	3.0	3.0	3.0	3.0
Total weight (g)	417.7	417.7	417.7	417.7

DTFP: Dried Trout Flesh Powder

Physical Analyses

Diameter, Thickness, Spread Ratio and Spread Factor of Biscuits

Biscuit weight, diameter and thickness (height) were measured 30 minutes after baking according to the AACC Method 10-31.03 [34]. Total weight, total diameter and height (at top center of each biscuit) of eight biscuits were measured (to 0.01 g), and results were reported for one biscuit. Spread ratio and spread factor of the biscuits were determined using the following formulas according to Manohar and Rao [35].
Spread Ratio = Biscuit Diameter / Biscuit Thickness
Spread Factor = Spread ratio of biscuits with DTFP added / Spread ratio of the control biscuit

Color of Biscuits

Color analysis was performed according to Krystyjan et al. [36]. Upper surface color of biscuits was measured using Konica MINOLTA CR-5 equipment (Konica Minolta, Inc., Tokyo, Japan) with D65 light source and a visual angle of 10°. The results were calculated with the CIE (*L**, *a**, *b*) system. The following parameters were measured: L^* (L^* = 0 black, L^* = 100 white), a^* ($a^* < 0$:green, $a^* > 0$: red), b^* ($b^* < 0$: blue, $b^* > 0$: yellow). At least six readings were recorded one hour after baking.

Mechanical Properties of Biscuits

Breaking strength and distance of ten individual biscuits were determined by a TA-XT Plus Texture Analyzer (Stable Micro Systems, Godalming, England) equipped with a 5 kg load cell and a three point bending rig. The analysis was carried out according to Jauharah et al. [37] with slight modifications. Operating conditions of the equipment was as follows; Pre test speed: 1.0 mm/s, test speed: 3.0 mm/s, post-test speed: 10 mm/s, trigger force: 5 g. Breaking strength was measured one hour after baking. Biscuit was centered on a base consisting of two support beams positioned at a distance of 3.2 cm. A third beam positioned equidistant from the two support beams, moved downwards until the biscuit was broken. Breaking strength, the force required to break the biscuit, was recorded as biscuit hardness (g force). Mean distance at break (mm was meaured as fracturability.

Chemical Composition of Biscuit

Moisture (AACC Method 44-15.02), ash (AACC Method 08-01.01) [38], fat (AOAC 963.15) protein (AOAC 955.04) [39] contents of the biscuits were determined. Carbohydrate content was calculated by subtracting the sum of moisture, ash, protein and fat values from 100. The 6.25 coefficient was used as nitrogen conversion to determine the crude protein content of biscuits.

Sensory Analysis of Biscuits

Sensory properties of the biscuits were evaluated using a 7-Point Hedonic Scale with the participation of 20 panelists (15 females, 5 males; aged 24-57), academic staff of Manisa Celal Bayar University Food Engineering Department. Sensory analysis was performed on the day of the biscuit production at 14.30 in the afternoon. Panelists were provided with drinking water to clean their mouth during sensory panel. They were asked to evaluate the randomly coded biscuits between 1-7 points (1: disliked extremely, 2: disliked, 3: disliked slightly, 4: neither liked nor disliked, 5: liked slightly, 6:

liked and 7: liked extremely) in terms of color, odor, crispiness, flavor, after-taste and overall acceptability [40]. After taste is the flavor remaining in the mouth one minute after the food is swallowed [41]. It was accepted that the panelists appreciated the samples with average overall acceptability score higher than 4 (neither liked nor disliked).

Statistical Analysis

Biscuits were produced in three replicates and all analysis were performed three times except for color analysis (6 parallels), breaking strength and distance (10 parallels). The mean values with the standard deviations were reported in tables. The one-way analysis of variance (ANOVA) and the Duncan's Multiple Comparison Test ($p < 0.05$) were used to determine differences among the mean values of physical, chemical and sensory properties of biscuits. Data were analyzed using Statistical Analysis Systems version 8.2 (1999–2001) software, SAS Institute Inc., Cary NC [42].

RESULTS AND DISCUSSION

Many changes take place in the biscuit dough during the baking process. Changes in dimension, loss of moisture and development of color and flavor are among the most important transformations. The dimensions of the end-product are crucial in the quality control of baked products [43]. Control biscuit and DTFP substituted biscuits were presented in Figure 1. Physical properties of control and DTFP substituted biscuits were shown in Table 2. The thickness of biscuits is a result of the biscuit structure by thermal denaturation of the gluten network and the expansion of the dough by the action of the aerating agents and the steam [44]. Gluten matrix was diluted by the substitution of wheat flour with DTFP in biscuits. As a result, thickness of DTFP added biscuits after baking was lower than the control biscuit. Similarly, Abraha et al. [9] conducted a study to determine the impact of sturgeon fillet powder supplementation (0%, 5%, 7% and 10%) on physical, chemical and sensory properties of sweet biscuits and reported a decrease in thickness of 7% and 10% fish fillet powder added biscuits. Ajila et al. [45] also showed the diluted gluten matrix as a reason for the decrease in biscuit thickness where wheat flour was replaced with 20% mango peel powder. Our results were consistent with these studies.

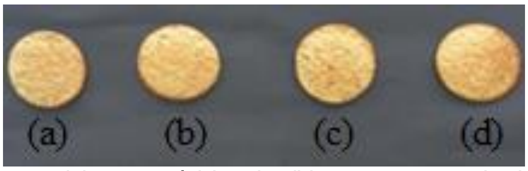

Figure 1. (a) Control biscuit, (b) 5% DTFP substituted biscuits, (c) 10% DTFP substituted biscuits, (d) 15% DTFP substituted biscuits

During the biscuit manufacturing process, the sheeting applies significant stresses to the dough, and the elastic components in the dough cause a gradual contraction of the dough sheet [46]. Pederson [47] stated that variability in the elastic recovery of biscuits can result in differences in the dimensions and weight of the biscuits. In the present study, weight of the biscuits decreased with DTFP substitution ($p<0.05$). Reduction in the weight of the biscuits substituted with DTFP may be a result of reduced biscuit thickness due to diluted gluten matrix and dough viscosity. As wheat flour consisting of gluten is replaced with DTFP, elastic recovery decreases, resulting in biscuit dough with lower contraction. So, thickness and weight decreases.

The spread ratio is an important physical property for products such as crackers and biscuits. Miller and Hoseney [48] reported that high spread ratio was a desirable quality property of biscuits. Spread ratio of biscuits increased with DTFP substitution. Similar to biscuit thickness and weight, the effect of DTFP substitution on the spread ratio of biscuits was statistically significant ($p <0.05$). 5, 10 and 15% DTFP substituted biscuits were statistically different from control biscuit but not different from each other in terms of spread ratio. Likewise our results, Silky and Tiwari [49], Baumgartner et al. [50] and Vijerathna et al. [51] reported in their studies that spread ratio increased in enriched biscuits. Abraha et al. [9] reported an increase in spread ratio from 11.43 (control) to 14.0 for 7% and to 14.33 for 10% fish fillet powder added biscuits. Results of this study was in accordance with our results.

Table 2. Physical properties of control and DTFP substituted biscuits

Biscuit type	Weight (g)	Diameter (mm)	Thickness (mm)	Spread Ratio	Spread Factor
Control	8.27±0.11^{a}	61.38±0.11^{ab}	4.73±0.04^{a}	13.03±0.01^{b}	1.00±0.00^{b}
5% DTFP	7.68±0.07^{c}	61.74±0.18^{a}	4.35±0.16^{b}	14.20±0.49^{a}	1.09±0.04^{a}
10% DTFP	8.04±0.22^{ab}	61.43±0.40^{ab}	4.28±0.11^{b}	14.35±0.44^{a}	1.11±0.04^{a}
15% DTFP	7.84±0.15^{bc}	60.90±0.26^{b}	4.20±0.08^{b}	14.58±0.12^{a}	1.12±0.01^{a}

In a column, means with different letter are significantly different from each other ($p<0.05$).

Spread factor is a measure of the diameter and thickness of the DTFP added biscuits relative to the control biscuit. Similar to thickness and spread ratio, spread factor did not differ among DTFP substituted biscuits, but differed from the control biscuit ($p <0.05$).

Breaking force of biscuits is an important feature affecting consumer acceptance [52]. The higher the breaking force is, the harder the food is. A previous study defined fracturability as the measurement of biscuits' resistance to bend and break. Biscuits that break at shorter distance have higher fracturability [37]. As seen from Figure 2, breaking strength and distance decreased with increasing DTFP substitution indicating reduced hardness and increased fracturability in comparison to control. 5% DTFP substituted biscuits did not differ from control sample statistically while 10 and 15% DTFP substituted biscuits resulted in decreased breaking strength and breaking distance. The reason for the decrease in breaking strength and distance was the reduced gluten matrix compared to control biscuits. Lower breaking strength and fracturability values measured in DTFP substituted biscuits in our study were associated with crispier texture. In line with our findings, Abraha et al. [9] reported decreased instrumental hardness values determined by 2 mm cylinder probe using Texture Analyzer for sturgeon fillet powder supplemented biscuits with respect to control biscuits. They notified 3167.25 g force for control biscuit and 2057.90 – 3089.02 g force for sturgeon fillet powder added biscuits.

Substitution of DTFP instead of wheat flour created important changes in the physical properties of biscuits. However, it was observed that the use of DTFP between 5-15% did not change most of the physical properties of the DTFP added biscuits. This is important in that the biscuit formulation allows high levels of enrichment component substitution. As a result, it is possible to improve the nutritional properties of the biscuits without changing the physical properties.

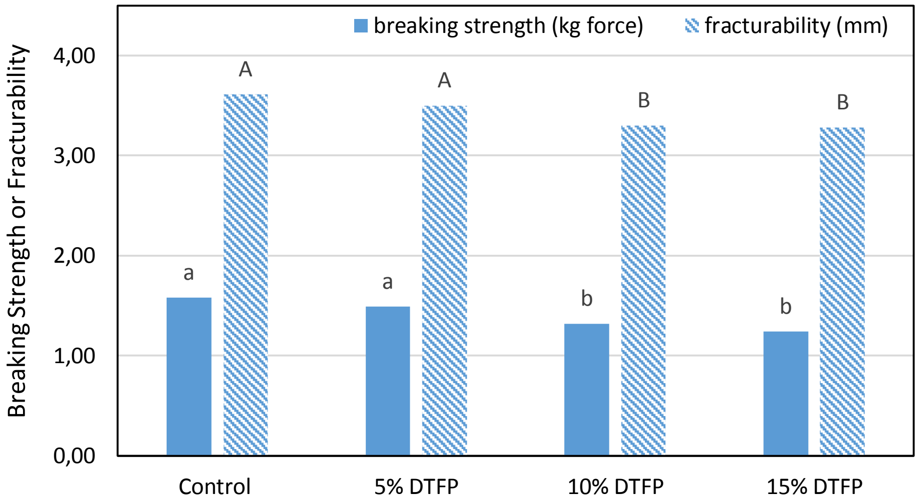

Figure 2. Breaking strength and fracturability of control and DTFP substituted biscuits. Different lowercase letters in breaking strength column are significantly different from each other ($p<0.05$). Different uppercase letters in fracturability column are significantly different from each other ($p<0.05$).

Color values of control and DTFP substituted biscuits were presented in Table 3. A slight decrease in *L** and *b** values was accompanied by a slight increase in *a** value with DTFP substitution. However, DTFP substitution did not affect *L** values of the biscuits ($p>0.05$) due to creamy color of DTFP, not deteriorating biscuit color. Adversely, DTFP substitution affected *a** values of the biscuits significantly ($p<0.05$) resulting in increased redness. 10 and 15% DTFP substituted biscuits were statistically different from control sample. DTFP substitution affected *b** values of biscuits, significantly ($p<0.05$). All DTFP substituted biscuits were different from control biscuit statistically ($p<0.05$). However, 5, 10 and 15% DTFP substituted biscuits were not different in terms of *b** values. In line with our study, Abou-Zaid and Mohamed [31] also reported Hunter *L and b* values slightly lower and *a* value slightly higher than control. *L, a* and *b* values were between 56.73 – 58.82, 12.68 – 13.32 and 22.10 – 25.74 for crayfish tail flesh powder added biscuits whereas they were 60.52, 11.25 and 25.52 for control biscuit. Similarly, Mohamed et al. [32] reported lower *L** values and slightly higher *a** values for 1-3% carp fish protein concentrate and 1-3% shark fish protein concentrate added biscuits in comparison to control biscuit. Abraha et al. [9] also found in their study that *L** value decreased slightly in 5% (79.92) and 7% (77.04) sturgeon fillet powder included biscuits, while 10% fish powder inclusion resulted in a sharper decrease (70.22) with respect to control biscuit (80.68). Similar to thickness, spread ratio and spread factor of biscuits, increasing substitution rates did not change biscuit color.

Table 3. CIE color values of control and DTFP substituted biscuits*

Biscuit type	L*	a*	b*
Control	$62.75{\pm}0.05^{a}$	$12.44{\pm}0.33^{b}$	$40.20{\pm}0.16^{a}$
5% DTFP	$62.09{\pm}0.21^{a}$	$13.05{\pm}0.33^{ba}$	$39.10{\pm}0.33^{b}$
10% DTFP	$61.06{\pm}0.25^{a}$	$14.26{\pm}0.13^{a}$	$38.86{\pm}0.06^{b}$
15% DTFP	$61.42{\pm}1.39^{a}$	$14.47{\pm}0.91^{a}$	$38.92{\pm}0.03^{b}$

*: In a column, means with different letter are significantly different from each other ($p<0.05$).

Chemical properties of the biscuits were presented in Table 4. DTFP substitution did not affect moisture content of the biscuits (p>0.05), while ash, fat, protein and carbohydrate contents of the biscuits were affected statistically (p<0.05). Ash and fat content of the biscuits increased by increasing DTFP substitution level in the range of 11.46 – 25.69% and 9.64 – 16.63%, respectively. The most pronounced increase (28.05 – 84.58%) was observed in protein content. This is an expected result as fish has high protein content. Seafood is one of the most valuable foods in terms of its nutritional components due to its high protein content [1]. As a result of increasing protein and ash content, carbohydrate content of biscuits decreased up to 12.86% by 15% DTFP substitution. Coradini et al. [29] prepared onion biscuits with the inclusion of 0%, 10%, 20% and 30% Nile tilapia carcasses. They reported protein, lipid, ash and carbohydrate contents as 15.34%, 12.21%, 3.64% and 62.65% for control biscuits, respectively. Likewise our results, Nile tilapia added biscuits exhibited increased protein (17.57 – 22.95%), ash (4.69 – 8.18%) and decreased carbohydrates (51.50 – 57.92%). Abou-Zaid and Mohamed [31] stated in their study that crayfish tail flesh powder and crayfish protein concentrate powder inclusion to biscuits increased protein from 9.15% to 11.60 – 16.08% and 11.73 – 16.29% respectively, with respect to control biscuit. In another study, Abraha et al. [9] also notified that crude protein, lipid and ash content of sturgeon fillet powder included biscuits were higher than control biscuit. Additionally, Ibrahim [33] studied the effect of 5% fish protein concentrate from tilapia byproducts on quality of salt-biscuits and reported increased protein in enriched biscuits (12.50%) in comparison to control (10.05%).

Table 4. Proximate composition control and DTFP substituted biscuits*

Biscuit type	Moisture (%)	Ash (%DM**)	Protein (%DM)	Fat (%DM)	Carbohydrates (%)
Control	3.82±0.91^{a}	2.88±0.11^{c}	6.81±0.16^{a}	14.31±0.07^{c}	72.19±0.71^{a}
5% DTFP	3.48±0.38^{a}	3.21±0.01^{b}	8.72±0.11^{b}	15.69±0.16^{b}	68.90±0.33^{b}
10% DTFP	3.77±0.64^{a}	3.50±0.06^{a}	10.69±0.06^{c}	16.70±0.05^{a}	65.34±0.70^{c}
15% DTFP	4.22±0.49^{a}	3.62±0.01^{a}	12.57±0.03^{d}	16.69±0.07^{a}	62.90±0.38^{d}

*: In a column, means with different letter are significantly different from each other (p<0.05). **DM: Dry matter.

Sensory properties of control and DTFP substituted biscuits were given in Table 5. Appearance of the biscuits was not affected from DTFP substitution significantly (p>0.05). The odor scores of all biscuits substituted with DTFP were similar to the control sample statistically (p>0.05). The odor score of biscuits substituted with 15% DTFP was significantly (p<0.05) higher than 5% and 10% DTFP substituted biscuits. Panelists evaluated biscuit crispiness as a measure of textural properties of biscuits and it was found that 5% DTFP substituted biscuits were different from control sample statistically (p<0.05), while 10 and 15% DTFP substituted biscuits were not different from control (p>0.05). Flavor of DTFP substituted biscuits were not different from control biscuit. Moreover, 15% DTFP substituted biscuits received higher flavor scores than other biscuits.

Table 5. Sensory properties of control and DTFP substituted biscuit

Biscuit type	Appearance	Odor	Crispiness	Flavor	After taste	Overall Acceptance
Control	5.82±0.17^{a}	5.18±0.08^{ba}	5.44±0.37^{a}	5.12±0.33^{ba}	5.32±0.04^{a}	5.29±0.17^{ba}
5% DTFP	5.74±0.29^{a}	4.85±0.04^{b}	4.94±0.08^{b}	4.47±0.42^{b}	4.76±0.17^{b}	4.74±0.12^{c}
10% DTFP	5.79±0.04^{a}	4.97±0.21^{b}	5.29±0.17^{ba}	5.04±0.13^{ba}	5.21±0.29^{ba}	5.08±0.12^{cb}
15% DTFP	6.06±0.17^{a}	5.35±0.42^{a}	5.33±0.17^{a}	5.82±0.17^{a}	5.61±0.11^{a}	5.71±0.21^{a}

In a column, means with different letter are significantly different from each other (p<0.05).

After taste scores showed that 15% DTFP substituted biscuits were appreciated as much as control biscuit while 5% DTFP substituted biscuits received lower after taste scores and was different from control biscuit. Overall acceptance is an important sensory attribute that determines consumer preference. Similar to texture and after taste, overall acceptance scores showed that 10 and 15% DTFP substituted biscuits were not different from control sample. 15% DTFP substituted biscuits even got higher scores than control sample. DTFP substitution resulted in sensorially acceptable biscuits especially in higher levels (10 and 15%). Abou-Zaid and Mohamed [31] reported that 3% and 6% crayfish protein concentrate powder inclusion did not affect general acceptance of biscuits. Moreover, sensorial crispiness of control and crayfish protein concentrate powder supplemented biscuits was not different statistically. Coradini et al. [29] stated that Nile tilapia inclusion did not affect sensorial properties of onion biscuits and 30% tilapia fortification was possible without deteriorating sensorial attributes of biscuits. Similarly, Abraha et al. [9] reported that 5, 7 and 10% sturgeon fillet powder included biscuits received similar sensorial scores and were not different from control biscuit statistically. İbrahim [33] found that color, odor, taste and overall acceptability scores of 5% fish protein concentrate from tilapia byproducts were not different from control biscuit. Mohamed et al. [32] also expressed that carp fish protein concentrate and shark fish protein concentrate inclusion at 1, 2 and 3% did not affect overall acceptability of biscuits adversely. Our results were in accordance with the literature, confirming that dried fish flesh powder inclusion to biscuits did not affect sensorial acceptability of biscuits adversely.

CONCLUSIONS

In the last years, demand for different types of health-oriented food products is increasing in the food industry. Fish is an excellent source of protein and amino acids, as well as high vitamin content and high biological value. Dried fish powders are favorable ingredients in the food industry as they have concentrated protein contents. This study show the potential for developing protein rich salty biscuits. The results of this study indicate that supplementation of wheat flour biscuits with 10 and 15% dried trout flesh powder ensured salty biscuits with increased protein and ash content, improved textural properties as well as acceptable sensorial properties. Dried trout flesh powder added salty biscuits enabled nutritious snack food for both children and adults. Especially, 10 and 15% trout flesh powder substituted biscuits received overall acceptance scores comparable with control biscuit. Overall, the incorporation of 10 and 15% dried trout flesh powder could provide salty biscuits and ultimately could contribute to solving problems of post harvest fish losses and children's malnutrition. Results of the present investigation could attract attention of manufacturers who are interested in producing protein rich snacks for children. Further studies can be conducted to determine mineral composition, as well as fatty acid and amino acid compositions of salty biscuits. Studies on bioaccessability of minor and major components are also of value.

REFERENCES

[1] Gülyavuz, H., Ünlüsayın, M. (1999). Su Ürünleri İşleme Teknolojisi. Şahin Matbaası, Ankara, 366s, ISBN 975-96897-0-7

[2] İzci, L., Ertan, O. (2004). Dumanlama işlemi uygulanmış kadife balığı (*Tinca tinca* L., 1758)'nın et verimi ve besin bileşimindeki değişimler. *Turkish Journal of Veterinary and Animal Sciences*, 28(6), 1037-1041.

[3] Schutz, H.G. and Judge, D.S. (1986). Changing needs and life-styles in developed countries. In: Taylor, T.G. and Jenkins, N.K. (eds.) Proceedings of the 13th International Congress of Nutrition. 18-23 August 1985. Brighton, UK, pp. 862-865.

[4] FAO (2018). The State of World Fisheries and Aquaculture 2018 - Meeting the sustainable development goals. Rome. Licence: CC BY-NC-SA 3.0 IGO.

[5] Regenstein, J.M., Regenstein, C.E. (1991). Introduction to fish technology, New York, Van Nostrand Reinhold. 280 pages, ISBN: 9780442005009.

[6] Ünlüsayın, M., Kaleli, S., Gülyavuz, H. (2001). The determination of flesh productivity and protein components of some fish species after hot smoking. *Journal of the Science of Food and Agriculture,* 81(7), 661-664.

[7] Oğuzhan, P., Angiş, S., Haliloğlu, H.İ., Atamanalp, M. (2006). Gökkuşağı Alabalığı (*Oncorhynchus mykiss*) Filetolarında Sıcak Tütsüleme Sonrası Kimyasal Kompozisyon Değişimleri. *Ege Üniversitesi Su Ürünleri Dergisi,* 23 (1/3), 465-466.

[8] Chattopadhyay, A.K., Rao, B.M., and Gupta, S. (2004). A simple process for the utilization of small bony fish as edible fish powder. *Fishery Technology,* 41(2), 117–120.

[9] Abraha, B., Mahmud, A., Admassu, H., Habte-Tsion, H.M., Xia, W., Yang, F. (2018). Production of biscuit from Chinese sturgeon fish fillet powder (*Acipeneser sinensis*): A snack food for children. *Journal of Aquatic Food Product Technology,* 27(10), 1048-1062.

[10] Meral, R., Doğan, İ.S. (2009). Fonksiyonel öneme sahip doğal bileşenlerin unlu mamullerin üretiminde kullanımı. *Gıda*, 34(3):193-198.

[11] Sudha M.L, Vetrimani R., Leelavathi K. (2007). Influence of fibre from different cereals on the rheological characteristics of wheat flour dough and on biscuit quality. *Food Chemistry*, 100(4):1365-1370.

[12] Beğen, F. (2012). Yüksek lif içerikli bisküvi üretiminde lüpen (*Lupinus albus* L.) kepeği kullanımı üzerine bir araştırma, Doktora tezi, Selçuk Üniversitesi Fen Bilimleri Enstitüsü, Gıda Mühendisliği Anabilim Dalı, 101 s.

[13] Goes, E.S.D.R., Souza, M.L.R.D., Michka, J.M.G., Kimura, K.S., Delbem, A.C.B., Gasparino, E. (2016). Fresh pasta enrichment with protein concentrate of tilapia: nutritional and sensory characteristics. *Food Science and Technology,* 36(1), 76-82.

[14] Monteiro, M.L.G., Marsico, E.T., Soares, M.S., Magalhães, A.O., Canto, A.C.V., Costa-Lima, B.R., Alvares, T.S., Conte, C.A. (2016). Nutritional profile and chemical stability of pasta fortified with tilapia (*Oreochromis niloticus*) flour. *PloS one*, 11(12), e0168270.

[15] Desai, A., Brennan, M.A., Brennan, C.S. (2018). The effect of semolina replacement with protein powder from fish (*Pseudophycis bachus*) on the physicochemical characteristics of pasta. *LWT-Food Science and Technology*, 89, 52-57.

[16] Özgören, E. (2019). Balık eti kullanımının makarnanın kalite özelliklerine etkisi. Doktora Tezi, Pamukkale Üniversitesi, Fen Bilimleri Enstitüsü, Gıda Mühendisliği Anabilim Dalı, 154 s.

[17] Cercel, F., Burluc, R. M., Alexe, P. (2016). Nutritional effects of added fish proteins in wheat flour bread. *Agriculture and Agricultural Science Procedia* 10, 244-249.

[18] Goes, E.S.D.R., Souza, M.L.R.D., Campelo, D.A.V., Yoshida, G.M., Xavier, T.O., Moura, L.B.D., Monteiro, A.R.G. (2015). Extruded snacks with the addition of different fish meals. *Food Science and Technology*, 35(4), 683-689.

[19] Justen A.P, Souza M.L.R.D, Monteiro A.R, Mikcha J.M, Gasparino E, Delbem Á.B, Del Vesco A.P. (2017). Preparation of extruded snacks with flavored flour obtained from the carcasses of Nile tilapia: physicochemical, sensory, and microbiological analysis. *Journal of Aquatic Food Product Technology*, 26(3), 258–266.

[20] Vitorino, K.C., Chambo, A.P.S., Coradini, M.F., Matiucci, M.A., Graton Michka, J.M., Goes, E.S.D.R., Gonçalvez, A.A., Souza, M.L.R.D. (2020). Cereal bars flavored with fish protein

concentrate from different species. *Journal of Aquatic Food Product Technology*, 29(1), 65-72.
[21] Huda, N., Abdullah, A., Babji, A.S. (2001). Substitution of tapioca flour with surimi powder in traditional crackers (Keropok Palembang). *16th Scientific Conference Nutrition Society of Malaysia*, 24-25 March 2001**,** Kuala Lumpur. Proceeding book 1-6 p.
[22] Nurul, H., Boni, I., Noryati, I. (2009). The effect of different ratios of dory fish to tapioka flour on the Linear expansion, oil absorbtion, color and hardness of fish crackers. *International Food Research Journal*, 16 (2), 159-165.
[23] Kaewmanee, T., Karrila, T.T., Benjakul, S. (2015). Effects of fish species on the characteristics of fish crackers, *International Food Research Journal,* 22(5), 2078-2087.
[24] Ramesh, R., Shakila, R. J., Sivaraman, B., Ganesan, P., Velayutham, P. (2018). Optimization of the gelatinization conditions to improve the expansion and crispiness of fish crackers using RSM. *LWT- Food Science and Technology*, 89, 248-25
[25] Zzaman, W., Yusoffand, M.M., Yang, T.A. (2017). Preparation and properties of fish cracker from different freshwater fish species. *International Food Research Journal*, 24(5), 1858-1862.
[26] Çamurdan, T. (2014). Sazan Balığı Kıymasından Balık Cipsi Üretimi ve Kalitesinin Belirlenmesi. Yüksek Lisans Tezi, Süleyman Demirel Üniversitesi, Fen Bilimleri Enstitüsü, Su Ürünleri Avlama ve İşleme Teknolojisi Anabilim Dalı. 43 s
[27] Tümerkan, T. (2015). Farklı Formülasyonlarda Üretilen Çorba ve Makarna Soslarına Balık Eti İlavesinin Besinsel Kompozisyon Üzerine Etkisi. Yüksek Lisans Tezi, Çukurova Üniversitesi, Fen Bilimleri Enstitüsü, Su Ürünleri Avlama ve İşleme Teknolojisi Anabilim Dalı. 70 s.
[28] Erdem, E. (2008). Tarhana Üretiminde Balık Etinin Kullanımı. Yüksek Lisans Tezi, Pamukkale Üniversitesi, Fen Bilimleri Enstitüsü, Gıda Mühendisliği Anabilim Dalı. 79 s.
[29] Coradini, M.F., Souza, M.L.R., Verdi, R., Goes, E.S.D.R., Kimura, K.S., Gasparino, E. (2015). Quality evaluation of onion biscuits with aromatized fishmeal from the carcasses of the Nile tilapia. Boletim do Instituto de Pesca, 41 (especial): 719-728.
[30] Bristone, C., Charles, A., Idakwo, P. (2017). Development of Nigerian based food like biscuit (Guliguli) from mixtures of sorghum, maize, soyanen, mmoringa leave and crayfish. *International Journal of Current Research*, 9(10), 59664-59671.
[31] Mohamed, G.F., Sulieman, A.M., Soliman, N.G., Bassiuny, S.S. (2014). Fortification of biscuits with fish protein concentrate. *World Journal of Dairy and Food Sciences*, 9(2), 242-9.
[32] Ibrahim, S.M. (2009). Evaluation of production and quality of salt-biscuits supplemented with fish protein concentrate. *World Journal of Dairy and Food Sciences* 4(1), 28-31.
[33] AACC (1999). Baking Quality of Biscuit Flour Method 10-31.03. AACC International Approved Methods. 1999, 1-3. DOI: 10.1094/AACCIntMethod-10-31.03.
[34] Manohar R.S., Rao P.H. (1997). Effects of water on the rheological characteristics of biscuit dough and quality of biscuits. *Journal of the Science of Food and Agriculture* 75, 383–390.
[35] Krystyjan, M., Gumul, D., Ziobro, R., Sikora, M. (2015). The effect of inulin as a fat replacement on dough and biscuit properties. *Journal of Food Quality,* 38(5), 305-315.
[36] Jauharah, M.A., Rosli, W.W., Robert, S.D. (2014). Physicochemical and sensorial evaluation of biscuit and muffin incorporated with young corn powder. *Sains Malaysiana*, 43(1), 45-52.
[37] AACC (2000). Approved Methods of American Association of Cereal Chemists. St. Paul, MN.
[38] AOAC (1990). Official Method Analysis of the Association of Official Analytical Chemists, 17th ed. Washington, DC.
[39] Watts, B.M., Ylimaki, G.L., Jeffery, L.E. (1989). Basic sensory methods for food evaluation. Ottawa: The International Development Research Centre. ON, CA.
[40] Altuğ Onoğur T., Elmacı, Y. (2011). Gıdalarda Duyusal Değerlendirme, Sidas Medya Ltd. Şti, Gülermat Matbaacılık, İzmir. ISBN: 978-9944-5660-8-7. 134 sayfa.
[41] S.A.S. (2001). Statistical Analytical Systems, SAS Users Guide: Statistics. SAS Institute Inc.
[42] Cronin, K., Preis, C. (2000). A statistical analysis of biscuit physical properties as affected by baking. *Journal of Food Engineering,* 46(4), 217–225.
[43] Mamat, H., Hardan, M.O.A., Hill, S.E. (2010). Physicochemical properties of commercial semi-sweet biscuit. *Food Chemistry* 121(4), 1029-1038.
[44] Ajila C.M., Leelavathi K., Prasada Rao U.J.S. (2008). Improvement of dietary fiber content and antioxidant properties in soft dough biscuits with the incorporation of mango peel powder. *Journal of Cereal Science,* 48(2), 319-326.
[45] Thacker, D. (1993). Evaluation of flour for biscuit making. In: Turner, A., (Ed.), Food Technology International Europe, Sterling Publications, London, pp. 154–158.
[46] Pedersen, L., Kaack, K., Bergsøe, M.N., Adler-Nissen, J. (2004). Rheological properties of biscuit dough from different cultivars, and relationship to baking characteristics. *Journal of Cereal Science*, 39(1), 37-46.
[47] Miller R.A., Hoseney R. (1997). Factors in hard wheat flour responsible for reduced cookie spread. *Cereal Chemistry*, 74 (3), 330-336.
[48] Silky, M.P.G, Tiwari, A. (2014). Development of high fibre biscuits using wheat bran. *International Journal of Engineering and Innovative Technology,* 4(6), 90-94
[49] Baumgartner B, Özkaya B, Saka I, Özkaya H. (2018). Functional and physical properties of cookies enriched with dephytinized oat bran. *Journal of Cereal Science*, 80, 24-30.
[50] Vijerathna M.P.G., Wijesekara I., Perera R., Maralanda S.M.T.A, Jayasinghe M., Wickramasinghe I. (2019). Physico-chemical characterization of cookies supplemented with

sugarcane bagasse fibres. *Vidyodaya Journal of Science,* 22(1), 29-39.
[51] Gaines C.S., Kassuba A., Finney P.L., Donelson J.R. (1992). Instrumental measurement of cookie hardness. II. Application to product quality variables. *Cereal Chemistry*, 69 (2),120-125.