The Journal of Animal & Plant Sciences, 29(3): 2019, Page: 842-847
ISSN: 1018-7081

PHYSICOCHEMICAL AND SENSORY EVALUATION OF FISH CHIPS MADE FROM *Luciobarbus esocinus* (Heckel, 1843)

N. K. Kuzgun

Fisheries Faculty, Munzur University, Tunceli, Turkey
Corresponding Author e-mail: nerminkaraton@hotmail.com

ABSTRACT

In this study, fish chips were produced using *Luciobarbus esocinus*, their fatty acids and amino acids profiles were determined and they were sensorially evaluated. For the preparation of experimental samples, *L. esocinus* meat was minced and added to a basic chips mixture. After that, the mixture was divided into in two: while pepper sauce was added to one half, the other half had no sauce added. The mixtures with sauce and without sauce were shaped into chips. Two samples of each batch of the chips prepared were cooked using two different methods (baking and frying). In this way four different groups were obtained. Analysis of fatty acids showed that the pre-frying and the pre-baking process resulted in a decrease in all fatty acids except for 18:1n-9 and 18:2n-6. Analysis of amino acids showed that isoleucine, lysine, threonine and, proline were present in the highest quantities respectively. After frying and baking the amounts of leucine, isoleucine, lysine, arginine, phenylalanine, and threonine decreased while the amounts of the valine and histidine remained at the same level. The essential amino acids for humans were found in the fish meat and in the fish chip groups, except for tryptophan. The general acceptability score of the fish chips was highest for group A which consisted of chips with sauce that had been fried (9.28±0.69).

Keywords: Fish chips, *Luciobarbus esocinus,* Fatty acids, Amino acids, Sensory evaluation.

INTRODUCTION

The worldwide demand for ready-to-eat products is constantly increasing. As a result of today's rapid pace of life, the consumption of fast foods has become increasingly popular, and the question of how to maintain a healthy and balanced diet is now an important issue in many societies. Fish is an excellent food to achieve this, and it can play a significant role in human nutrition.

The potential benefits of consuming fish come from the presence of proteins, minerals, vitamins and essential unsaturated fatty acids (Güler *et al.,* 2008). Amino acids are essential for health; a lack of them leads to a number of diseases (Mohanty *et al.,* 2014). Fish protein has a high nutritive value due to the essential amino acids that it contains (Beklevük *et al.,* 2005; Larsen *et al.,* 2007).

Potato chips are a popular consumer good in Turkey and they are eaten by people of all ages. In recent years, per capita consumption of chips has increased at a great rate in both Turkey and around the world (Karaton Kuzgun, 2017). Many different varieties of these products are currently available in the consumer marketplace. Adding fish supplements to these types of product should be seriously considered for the purposes of promoting health (Egemen, 1986; Richardson, 1990; Ekşi and Karadeniz 1996; Karagözlü *et al.*, 2000; Obatoluve and Cole, 2000). In a study conducted on the Tigris asp (*Aspius vorax*), Duman *et al.,* (2013) obtained surimi powder and produced fish chips using different proportions of this powder. In an organoleptic evaluation of flavor and taste, the chips with a 5% proportion of the powder received the highest scores from the panelists. Dinçer *et al.,* (2015) produced sardine chips. They investigated the chemical composition, shelf life and fatty acid composition of those products. Uzun *et al.* (2006) determined the nutritional composition and energy values of a number of different potato and corn chips produced in Turkey. Karaton Kuzgun (2017) determined the proximate composition and organoleptic properties of fish chips. According to the results of this research, a group of panelists (n=65) liked the group of fried fish chips most. Nevertheless, only a limited of studies to date have fully investigated the fatty acid and amino acid content of fish meat-enriched chips.

The current study was designed the evaluate to investigate the use of *L. esocinus* in the production of fish chips and determine changes in physicochemical levels as a result of the different cooking techniques used.

MATERIALS AND METHODS

Preparation of the fish: In this study, high-value *L. esocinus* (Heckel, 1843) was caught in the Keban Dam Lake. The fish was transported to the laboratory in Styrofoam boxes with ice.

Preparation of chips samples: Fish chips were prepared by following the method of Göğüş and Kolsarıcı (1992) in a modified form. The fish brought to the laboratory

was decapitated and skinless fillets were produced. The basic mixture for the fish chips consisted of 680g minced fish, 200g corn starch, 500ml cold water, 300g flour, 300 corn flour, 25g salt and 7g thyme. For the groups with sauce, 30g of pepper sauce containing 3g of pepper was added. The resulting mixture was blended in order to obtain a paste with a homogeneous consistency. This paste was first compressed with a 0.7 mm extractor and then passed through a double-walled extractor (Ampia, 150, Italy). After the product had been molded into chips, half of the groups were fried with sauce and without sauce for three minutes at 180 °C in sunflower oil and the remaining half was baked for five minutes at 180 °C in the oven. Thus, the groups with sauce and without sauce were both cooked with two different cooking methods, resulting in four different experimental groups: Fried with sauce (A), Fried without sauce (B), Baked with sauce (C), Baked without sauce (D). The study was replicated twice.

Fatty acid methyl ester (FAME) analysis: In order to conduct the chromatographic analysis of the fatty acids found in lipids, they need to be transformed into non-polar, volatile and stable methyl ester derivatives. Methyl esters were obtained by a small modification of the method reported by TS EN ISO 12966-1, (2015). Lipid samples were diluted with 2ml of n-heptane in a clean, stoppered tube and 0.2 mL of potassium hydroxide (2 N KOH in methanol) was added. The mixture was vortexed for 30 seconds at room temperature and centrifuged at 4000 rpm for ten minutes. Finally, the top layer was separated for FAME analysis.

Gas chromatographic condition: Analysis of fatty acid methyl esters was performed using a Shimatzu GC-2010 device. Injector and detector temperatures were maintained at 250°C and 270°C respectively. The furnace temperature was also maintained at 90-240°C. Fatty acids were identified by comparing them with the standard FAME mixture consisting of 37 items. The results of GC analysis were expressed as % ± standard error (TS EN ISO 12966-1, 2015).

Amino acid analysis: For amino acid analysis, the samples were fired with 6 N HCl at 150 °C for 2 hours, then filtered through a 45 µ filter. In determining the free amino acid composition of the samples, the HPLC method described by Aristoy and Toldra, (1991) and Antoine *et al.* (1999) was used. Elution Buffer A Na_2HPO_4, $Na_2B_4O_7$ and NaN_3 (pH 8.2) and Elusion Buffer B acetonitrile: methyl alcohol: water (45:45:10) were used. A prominence fluorescence detector and Zorbax Eclipse-AAA 4.6 x 150 mm, 3.5 µm HPLC (Shimadzu LC-20 AT Prominence Liquid Chromatograph) were used to determine the free amino acid composition of the samples. OPA (ortho-phthalaldehyde) and FMOC (9-fluorenylmethyl chloroformate) were used as the derivatization reagents for amino acids and then, 0.4 N borate (pH: 10.2) was used as the buffer solution. Readings were conducted at 1.5 ml/min flow rate, 2% Buffer B concentration, and for 40 min. After the procedures mentioned above, amino acids such as valine, leucine, isoleucine, lysine, methionine, phenylalanine, arginine, histidine, threonine, tyrosine, aspartic acid, serine, asparagine, glutamine, glycine, alanine, cysteine, and proline were tested with an RF20A detector.

Sensory analysis: Five experienced panelists, who were academic staff trained in sensory descriptors, evaluated the quality of the fish chips. Panelists evaluated the samples' appearance, odor, color, flavor, crispiness, fish odor and general acceptability on a 10-point hedonic scale ranging from 'Cannot be consumed' (1) to 'Excellent' (10) (Altuğ Onoğur and Elmacı, 2011).

Statistical analysis: IBM SPSS®22 (SPSS Inc., Chicago, IL, USA) statistical package software was employed for the statistical analysis of the data acquired in this study. The statistical significance of the differences among groups was investigated by means of variance analysis (One- Way ANOVA), using Duncan's (Duncan, 1955) multiple range test. The $p<0.05$ was considered significant (Özdamar, 2001).

RESULTS AND DISCUSSION

Fatty acids composition: A total of 16 fatty acids were identified in the lipids of *L. esocinus* meat, the chips mixture, and chips samples (Table 1). The fatty acid composition of the fish chips made with *L. esocinus* is given in Table 1. The major fatty acids in the fish meat included palmitic (21.58±1.48 mg/100 g), stearic (3.79±0.13 mg/100 g), oleic (23.87±0.86 mg/100 g), linoleic (5.32±0.26 mg/100 g) and linolenic (5.23±0.63 mg/100 g) acids. In a separate study, the fatty acids found in the largest quantities in samples of *A. Boyeri* were palmitic at 27.1±3.2 mg/100 g, oleic at 4.6±0.3 mg/100 g and docosahexaenoic acid at 24.8 ±3.9 mg/100 g (Tanakol *et al.,* 1999). The findings of this study are similar to our study findings. Among the fatty acids of greatest nutritional importance, the n-3 series stands out. Oleic acid (18:1n9) was found at levels of 22.62±0.59, 30.37±0.27, 30.07±0.07, 23.50±0.41 and 23.01±0.00 mg/100 g in the chips mixture and the A, B, C and D samples respectively (Table 1). In this study, there was a significant difference ($p<0.05$) in the amount of oleic acid (18:1n9) between the groups. On the other hand, linoleic acid (18:2n6) was found to be 30.19±0.18 mg/100 g in the fried samples without sauce, the maximum ratio within the chips produced (Table 1). The ratios of the fatty acids DHA/EPA found during the stages of the chips' production (fish meat, chips mixture, fried chips with sauce, fried chips without sauce, baked chips with

sauce and baked chips without sauce) respectively were 1.52±0.05, 2.41±0.34, 1.24±0.02, 1.18±0.01, 3.03±0.01 and 3.05±0.03 mg/100 g (Table 1). The values of DHA/EPA in the samples are in accordance with those findings obtained by other authors (İzci *et al.,* 2011). The n-6/n-3 fatty acid ratios during the production of the chips were found to be 1.66±0.38, 1.43±0.51, 4.63±0.03, 5.22±0.02, 1.89±0.02 and 1.63±0.08 mg/100 g (fish meat, chips mixture, fried chips with sauce, fried chips without sauce, baked chips with sauce and baked chips without sauce, respectively) and there significant differences were observed throughout the process ($p<0.05$) (Table 2). This hypothesis is supported by the results determined by İzci *et al*., (2011). According to this hypotehesis, İzci *et al.,* (2011) determined the qualities of fish chips produced from *Atherina Boyeri* and İzci *et al.,* (2011) also found that pre-frying in sunflower oil resulted in a decrease in all fatty acids except for 18:1n-9 and 18:2n-6. Neiva *et al.,* (2011) produced minced fish using equal proportions of two low-value fish species. The level of n-6 fatty acids was higher in fried crackers than the level of n-6 fatty acids in crackers cooked in the microwave, but the total n-3 fatty acid density was higher in the latter crackers. The findings of this study parallel our research findings.

Table1. Fatty acid profile of fish chips (mg 100 g).

Symbol	*Fish*	*Dough*	*A*	*B*	*C*	*D*
14:0	0.77±0.09^{a}	0.57±0.06^{b}	0.47±0.01^{b}	0.47±0.01^{b}	0.49±0.01^{b}	0.54±0.02^{b}
16:0	21.58±1.48^{c}	18.53±1.01^{bc}	9.04±0.94^{a}	8.67±1.07^{a}	18.02±0.01^{b}	18.02±0.01^{b}
16:1	11.72±0.36^{c}	10.18±0.14^{b}	1.44±0.01^{a}	0.94±0.01^{a}	12.14±0.13^{c}	11.80±0.79^{c}
18:0	3.79±0.13^{bc}	2.12±0.11^{a}	4.11±0.02^{c}	3.49±0.41^{bc}	3.35±0.04^{b}	3.20±0.20^{b}
18:1n9	23.87±0.86^{a}	22.62±0.59^{a}	30.37±0.27^{b}	30.07±0.07^{b}	23.50±0.41^{a}	23.01±0.00^{a}
18:2n6	5.32±0.26^{a}	11.77±0.56^{b}	29.67±0.33^{e}	30.19±0.18^{e}	14.88±0.10^{d}	13.67±0.22^{c}
18:3n3	5.23±0.63^{c}	4.31±0.02^{b}	0.59±0.02^{a}	0.47±0.00^{a}	3.63±0.03^{b}	3.87±0.01^{b}
20:3n6	6.58±0.00^{f}	4.11±0.01^{c}	3.55±0.00^{b}	3.44±0.00^{a}	4.11±0.01^{e}	4.10±0.01^{d}
20:4n6	3.52±0.03^{d}	1.39±0.06^{c}	0.88±0.03^{b}	0.87±0.01^{b}	0.39±0.01^{a}	0.43±0.00^{a}
20:5n3	2.51±0.26^{c}	1.57±0.23^{b}	1.97±0.01^{b}	1.75±0.03^{b}	0.98±0.01^{a}	0.96±0.00^{a}
22:0	1.74±0.05^{c}	0.92±0.05^{b}	1.75±0.06^{c}	2.04±0.05^{d}	0.04±0.00^{a}	0.04±0.00^{a}
22:2	0.91±0.06^{c}	5.51±0.00^{b}	3.53±0.00^{c}	4.87±0.01^{d}	4.86±0.05^{a}	5.93±0.04^{a}
22:1n9	0.42±0.13^{a}	0.23±0.05^{a}	1.69±0.00^{b}	2.12±0.08^{c}	0.33±0.03^{a}	0.33±0.02^{a}
24:0	2.43±0.33	2.34±0.00	1.78±0.01	1.40±0.01	3.85±0.14	4.82±0.31
24:1	0.97±0.02^{d}	0.51±0.02^{b}	0.85±0.04^{c}	0.77±0.04^{c}	0.29±0.02^{a}	0.21±0.01^{a}
22:6n3	3.72±0.29^{b}	2.78±0.01^{a}	4.46±0.02^{c}	4.08±0.05^{bc}	4.98±0.01^{d}	4.94±0.04^{d}
n6/n3	1.66±0.38^{a}	1.43±0.51^{a}	4.63±0.03^{b}	5.22±0.02^{b}	1.89±0.02^{a}	1.63±0.08^{a}
PUFA/SFA	0.87±0.02^{a}	1.02±0.05^{a}	1.94±0.13^{b}	2.09±0.19^{b}	0.92±0.01^{a}	0.86±0.02^{a}
DHA/EPA	1.52±0.05^{a}	2.41±0.34^{b}	1.24±0.02^{a}	1.18±0.01^{a}	3.03±0.01^{c}	3.05±0.03^{c}

(A) Fried with sauce, (B) Fried without sauce, (C) Baked with sauce, (D) Baked without sauce

^{a,b,c,d,e,f}: Different letters in the same line show significant differences among all values ($p<0.05$, based on Duncan test). Values are means X± Sx of two replicate sample.

Table 2. Anova data.

Symbol		*Ss*	*Df*	*Ms*	*F*-value	*Sig.*
n6/n3	Between Groups	29.092	5	5.818	41.206	0.000
	Within Groups	0.847	6	0.141		
	Total	29.939	11			
DHA/EPA	Between Groups	7.546	5	1.509	39.026	0.000
	Within Groups	0.232	6	0.039		
	Total	7.778	11			
PUFA/SFA	Between Groups	4.273	5	0.855	9.570	0.008
	Within Groups	0.536	6	0.089		
	Total	4.809	11			

Ss: Sum of square, Df: Degree of freedom, Ms: Mean square,

Amino acid composition: The method used in this study enabled the analysis of 18 amino acids. Table 3 shows the amino acid profiles of the fish chips. The amounts of total amino acids (TAA) were found to be 23.82g/100g in the fish meat, 3.99g/100g in the chips mixture, 6.79g/100g in the chips fried with sauce, 4.44g/100g in the chips fried

without sauce, 7.94g/100g in the chips baked with sauce and 11.05g/100g in the chips baked without sauce. The amount of leucine, isoleucine, lysine, arginine, phenylalanine, and threonine decreased while the amount of the valine and histidine remained at the same level after frying and baking. All the essential amino acids for humans, except tryptophan, were found in the fish meat and in the fish chips groups. Ayas, (2006) reported that the decline in the amount of protein in smoked fillets was associated with loss of proteins, small peptides and amino acids during cooking. Berik *et al.* (2011) reported that the total amount of amino acids in fish fingers was 16.5g/100g in fish meat, 14g/100g in fish finger paste and 13.2g/100g in fried fish fingers. Çankırılıgil and Berik (2017) reported that amino acid analyses showed that the highest amounts of glutamic acid, lysine, leucine and the essential amino acids for humans (except for tryptophan) were found in sardine meat and croquettes. The findings of this study show parallelism with our findings.

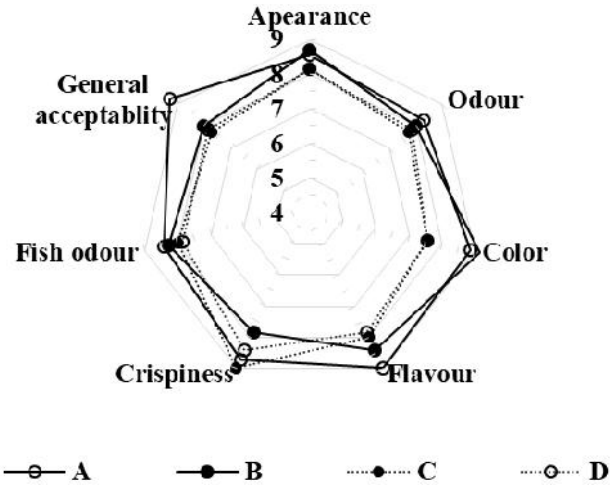
Table 3. Amino acid composition of fish chips (g/100g).

Amino acids	Fish	Dough	A	B	C	D
			Essential Amino Acids			
Valine	0.01	0.00	0.01	0.01	0.00	0.02
Leucine	0.12	0.00	0.04	0.01	0.01	0.08
Isoleucine	10.20	2.01	3.06	1.51	4.01	5.49
Lysine	2.91	0.20	1.00	0.22	0.37	0.41
Methionine	0.01	0.01	0.05	0.01	0.06	0.05
Phenylalanine	0.15	0.03	0.04	0.02	0.07	0.08
Arginine	0.54	0.05	0.21	0.07	0.10	0.22
Histidine	0.05	0.02	0.08	0.04	0.04	0.04
Threonine	1.72	0.24	0.33	0.10	0.30	0.47
			Non-Essential Amino Acids			
Tyrosine	0.88	0.05	0.05	0.02	0.05	0.08
Aspartic acid	0.96	0.03	0.31	0.15	0.07	0.08
Serine	0.38	0.16	0.29	0.08	0.40	0.45
Aspargine	0.00	0.00	0.30	0.12	0.00	0.00
Glutamine	0.01	0.01	0.01	0.04	0.01	0.01
Glycine	0.02	0.01	0.00	0.01	0.00	0.00
Alanine	0.46	0.49	0.01	0.03	0.01	0.01
Cystine	0.05	0.01	0.00	0.01	0.01	0.01
Proline	5.35	0.67	1.00	1.99	2.43	3.55
			Evaluating Parameters			
TEAA	15.71	2.56	4.82	1.99	4.96	6.86
TAA	23.82	3.99	6.79	4.44	7.94	11.05

TEAA:Total essential amino acids; TAA:Total amino acids
(A) Fried with sauce. (B) Fried without sauce. (C) Baked with sauce. (D) Baked without sauce

Sensory evaluation: As seen in Fig. 1. the B group samples received the highest score with 8.71 ± 1.27 when the chips were evaluated based on appearance; the C group samples received the lowest score. There were no significant differences between the groups based on differences in appearance in the study ($p > 0.05$). When the experimental groups were examined for odour. group A received the highest score (8.28 ± 0.45) and the samples that had only been baked received the lowest score (7.71 ± 1.03) (Fig. 1). There was no significant difference based on difference in odour between the groups ($p > 0.05$). The color score for the chips was in the interval 9.14 ± 0.98 - 7.57 ± 1.04 points (Fig. 1). There were statistically significant differences between fish chip groups according to the color scores ($p < 0.05$). As seen in Fig. 1. when the experimental fish chips were evaluated for flavor. fried chips in group A received the highest flavor score. However. There was no significant difference between the chip groups in terms of flavor score ($p > 0.05$). The differences between experimental sample groups were not statistically significant ($p > 0.05$) when the *L. esocinus*-enriched chips samples were reviewed by the panelists for crispness; and the group scores were similar as well (Fig. 1). Based on the scores given by the panelists. It was pointed out that the chips with the sauce that had been fried were their favorite (9.28 ± 0.69); and the ones they liked least were those with sauce that had been baked (7.71 ± 1.05) (Fig. 1). The difference between the experimental groups was significant ($p < 0.05$). In their study. İzci *et al.*. (2011) determined the general acceptability score for their chips to be 8.33 ± 0.18. This result is consistent with the

findings of the present study. Yüksel *et al*.. (2014) enriched wheat chips with omega-3 fatty acid by adding flaxseed. They found that panelists gave higher sensory scores to the flaxseed-enriched wheat chip samples.



(A)Fried with sauce. (B) Fried without sauce. (C) Baked with sauce. (D) Baked without sauce

Fig.1. Sensory changes in fish chips

Conclusion: Chips consumed worldwide in the form of products with low nutritional value. such as potato chips and corn chips, can be supplemented with fish for the purpose of enhancing their nutritional value. Furthermore. fish chips produced in this way could be marketed to consumers as fast food. By adding various spices and different sauces the range of products available could be expanded. Thus also contributing to the development of the global economy and also, The lipid characteristics and amino acid contents of fish chips made using fish meat vary according to the cooking methods. The losses in content of DHA and EPA in cooking with frying method is higher than other methods.

REFERENCES

Altuğ Onoğur. T. and Y. Elmacı (2011). Gıdalarda Duyusal Değerlendirme; Sidas Medya. İzmir.

Antoine. F.R.. C.I.Wei. R.C. Littell. and M.R. Marshall (1999). HPLC method for analysis of free amino acids in fish using o-phthaldialdehyde precolumn derivatization. J. of Agri. and Food Chem. 47:5100-5107.

Aristoy. M.C. and Õ.F. Toldra (1991). Deproteinization techniques for HPLC amino acid analysis in fresh pork muscle and dry- cured ham. J. of Agri. and Food Chem. 39:1792–1795.

Ayas. D. (2006). The differences in whole body chemical composition of the rainbow trout (*Oncorhyncus mykiss*). Black Sea pilchard (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) following hot smoking. Ege J. Fish. and Aq. Sci. 23(1–3): 343–346.

Beklevük. G.. A. Polat. and F. Özoğul (2005). Nutritional Value of Sea Bass (*Dicentrarchus labrax*) Fillets during Frozen (-18°C) Storage. Turk J Vet Anim Sci.. 29:891-895

Berik. N.. C. Cankiriligil. and D. Kahraman (2011). Determination of quality attributes and production of fingers from rainbow trout (*Oncorhynchus mykiss*) fillet. K. U. Vet. Fak. Dergisi. 17(5): 735–740.

Çankırılıgil. E.Ç. and N. Berik (2017). Effects of deep-frying to sardine croquettes' chemical composition. Ege J. of Fish. and Aq. Sciences. 34(3): 293-302.

Dinçer. T.. H. Sargın. A.B. Yavuz. Ç. Üçok. and B. Pir (2015). Sardalya (*Sardina pilchardus*) içerikli cips üretimi ve raf ömrü. 18. Ulusal su ürünleri sempozyumu. 1-4 September. İzmir.

Duman. M.. E. Özpolat. and M.R. Gül (2013). The chips produced using surimi powder different rates of chemical composition and sensory quality determination. J. Fisheries Sciences.com. 6(4):282-286.

Duncan, D.B. (1955). Multiple range and multiple f test. Biometrics. 11: 1-42.

Egemen. A. (1986).Vitaminlerin Sağlığımızdaki Önemi' Konulu Sempozyum Notları. İzmir 119 p.

Ekşi. A. and F. Karadeniz (1996). Gıda Zenginleştirme Yaklaşımı ve Türkiye'de Uygulama Olanağı. Besl. ve Diyet Derg. 25(2):45-51.

Göğüş. A.K. and N. Kolsarıcı (1992). Su Ürünleri İşleme Teknolojisi. Ankara Üniversitesi. Ziraat Fakültesi Yayınları. Ankara. No:1243.

Güler. G.O.. B. Kiztanir. A. Aktumşek. O.B. Citil. and H. Özparlak (2008). Determinetion of the seasonal changes on total fatty acid composition and ω3/ω6 ratios of carp (*Cyprinus carpio* L.) muscle lipids in Beyşehir Lake (Turkey). Food Chem. 108(2):689-694.
http://dx.doi.org/10.1016/j.foodchem.2007.10.080. PMid:26059149.

İzci. L.. A. Günlü. and Ş. Bilgin (2011). Production of Fish Chips from Sand Smelt (*Atherina boyeri*. RISSO 1810) and Determination of Some Quality Changes. Iranian J. Fish. Sci. 10(2):230 241.

Karagözlü. C.. N. Akbulut. and S. Ömeroğlu (2000). Zenginleştirilmiş Süt ve Süt Ürünleri. Süt Mikrobiyolojisi ve Katkı Maddeleri VI. Süt ve Süt Ürünleri Sempozyumu. Tebliğler Kitabı. Tekirdağ. 595 p.

Karaton Kuzgun. N. (2017). Determination of Proximate Composition and Sensory Quality of The Fish Chips Obtained from *Luciobarbus esocinus*

(Heckel 1843). S. D. Ü. Eğirdir Su Ürünleri Fakültesi Dergisi. 13(2):153-162.

Larsen. R.. S.K. Stormo. B.T. Dragnes. and E.O. Elvevoll (2007). Losses of taurine. creatine. glycine and alanine from cod (*Gadus Morhua L.*) fillet during processing. J. Food Compos. Anal. 20:396-402.

Mohanty. B.. A. Mahanty. S. Ganguly. T.V. Sankar. K. Chakraborty. A. Rangasamy. and A.P. Sharmal (2014). Amino acid compositions of 27 food fishes and their importance in clinical nutrition. J. of Amino Acids. 7–14. doi: 10.1155/2014/269797

Neiva. C.R.P.. T.M. Machado. R.Y. Tomita. E.F. Furlan. M.J. Lemos Neto. and D.H.M. Bastos (2011). Fish crackers development from minced fish and starch: an innovative approach to a traditional product. Cién. e Tecn. de Alim. 31(4):973-979. http://dx.doi.org/10.1590/S0101-20612011000400024.

Obatolu. V.A. and A.H. Cole (2000). Functional Property of Complementary Blends of Soybean and Cowpea with Malted or Unmalted Maize. Food Chem. 70:147-153.

Özdamar. K. (2001). SPSS ile Biyoistatistik. No: 3.4. Baskı. Kaan Kitabevi. Eskişehir. 452 p.

Rıchardson. D.P. (1990). Food Fortification. Proceed. of the Nutr. Soc. 49:39-50.

Tanakol. R.. Z. Yazıcı. E. Şener. and E. Sencer (1999). Fatty acid composition of 19 species of fish from the Black Sea and the Marmara Sea. Lipids. 34(3):291-297.

TS EN ISO 12966-1. (2015). Animal and vegetable fats and oils - Gas chromatography of fatty acid methyl esters - Part 1: Guidelines on modern gas chromatography of fatty acid methyl esters. 19.

Uzun. Ö.. C. Yağmur. and E.A. Özer (2006). Türkiye'de üretilen bazı patates ve mısır cipslerinin besin bileşimleri ve enerji değerlerinin belirlenmesi. standartlara ve etiket bilgilerine uygunluğunun incelenmesi. V. International Congress of Nutrition and Dietetics. 12-15 April. 2006. Ankara.

Yüksel. F.. S. Karaman. and A. Kayacier (2014). Enrichment of wheat chips with omega-3 fatty acid by flaxseed addition: Textural and some physicochemical properties. Food Chem. 145:910–917.