Production of Fish Chips from Sand Smelt (*Atherina boyeri*, RISSO 1810) and Determination of Some Quality Changes

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Abstract

In this study, changes in some quality parameters of fish chips produced from sand smelt (*Atherina boyeri*, RISSO 1810) during storage period (at -18 ^{o} C for 6 months) were determined. The difference between the amount of moisture, crude protein, crude fat and crude ash components of raw fish in fish chips was significant ($P<0.05$). Pre-frying process resulted in a decrease in all fatty acid compositions except for $C_{18:1\ \omega-9}$ and $C_{18:2\ \omega-6}$.Difference between the pH and thiobarbituric acid (TBA, µg malonaldehyde/g) values of raw fish meat and pre-fried chips was insignificant ($P>0.05$). However, total volatile basic nitrogen (TVB-N, mg/100g) value was changed significantly ($P<0.05$) between raw fish meat and pre-fried chips. The results of sensory analyses made by panelists were as follows; fish chips enjoyed it very much. The results of chemical, sensory and microbiological analyses of fish chips performed following frozen storage period at -18 ^{o}C for 6 months were within the acceptable limits.

Keywords: Sand smelt, *Atherine boyeri*, Fish Chips, Quality changes, Fatty acids

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Introduction

As the population of the world has risen rapidly, current food sources should be better evaluated. Nowadays, as the tempo of life increases, food consumption as "heat and eat" has become the way of life. Thus, food sector has become one of the most important sectors.Nowadays, as parallel to the increasing business tempo, the consumption of food as "heat and eat" has become important. Food sector has taken place of the most important sectors amongst all current sectors.According to FAO statistics, worldwide consumption of fishery products per capita is 16 kg/year on average and 22 kg/year EU in the countries, but it is about 8 kg/year in Turkey (Taş, 2007). Thus, we are quite under in terms of fish consuming.

For uneconomical fish species in both Turkey and other countries, it is very important to increase their economic value. *A. boyeri* population has increased in the Lake of Eğirdir in the recent years and this fish species is not economical. Therefore, this species was selected for the study.

Kalogeropoulos et al., (2004) carried out the nutritional evaluation of raw and pan-fried *A. boyeri*. In a study which was carried out to determine the microbiological quality of fresh and processed *A. boyeri*, it was determined the total aerobic bacteria, coliform and fecal *streptococcus* numbers (Çolakoğlu et al., 2006). When compared to conventional packaging, Modified Atmosphere Packaging (MAP) process increased the shelf life of fish balls (Baygar et al., 2008). Varlık et al. (2000) reported that, shelf life of marinated fish ball is 120 day at 4±1 ^{o}C.

It is thought that sand smelt (*Atherina boyeri*, RISSO 1810) could be obtain a different taste through producing fish chips, its consumption could be widespread, and by this way, its economical value could be increased. Furthermore, in this study has been aimed to determine some chemical, sensorial, and microbiological changes occurring in the product stored at -18 ^{o}C.

Material and methods

In this research, sand smelt (*A. boyeri*) was provided from Eğirdir Cooperative of Fishery Products, and it was sent to the Food Laboratory in Eğirdir Faculty of Fisheries within thirty minutes. First of all, the heads and internal organs were thrown, and their fillets were removed. After separating some of these fillets for analysis, using modified method of Varlık et al. (2004) and Food and Agriculture Organization (FAO) (2007) the remaining parts were used for "fish chips".

For the fish chips, the mixture was derived from 60.00 % minced fish, 11.00 % starch, 21.00 % cold water, 5.50 % potato flour, 1.85 % salt, and 0.65 % monosodium glutamate (MSG). The mixture was 10 cm long and 1 cm thick. After frying in sun flower oil at the temperature of 190 ^{o}C for 6 seconds, it was frozen (shocked) at -80° C and kept within plastic cases, covered and stored at -18° C.

The analysis of food components was performed on every sample of sand smelt. In addition to analyses for the chemical parameters of the samples stored at -18° C on the 1st, 30th, 60th, 90th, 120th, 150th, and 180th days, sensory and microbiological analyses were also carried out. In this analysis, moisture was determined by the automatic moisture

device (AND MX-50), crude protein by Velp UD-20 protein pre-burning unit and full automatic Velp UDK 142 protein distillation unit, according to Kjeldahl method (Nx6,25) Association of offical analytical chemists, (AOAC) (2000). Crude fat was done according to (Lovell, 1975) while crude ash was done according to Lovell (1981). In the microbiological analysis, Total Mesophilic Aerobic microorganism (TMA), Total Psicrophilic Aerobic microorganism (TPA), Coliform Number and Yeast-Mould number were determined (Anonymous, 1994; Arslan et al., 1997; International Commission on Microbiological Specifications for Foods (ICMSF), 1978; Refai, 1979). The sensory analysis of the fish chip was performed including color, odor, flavour, texture and general acceptability giving from 1 to 9 points at hedonic scale with the method reported by Tokur et al. (2006).

pH analysis was carried out using WTW mark 320 sets digital pH meter which probe could perform measuring directly from meat. TBA (Thiobarbituric acid) was determined as described by Erkan and Özden (2008) with the reported method from Weilmeier and Regenstein (2004) and Khan et al. (2006).TVB-N (Total Volatile Basic Nitrogen) values were estimated using the method described by Nicholas (2003). Fatty acid profile was determined by gas chromatography after methylation with sodium metoxide according to methods of Izquierdo et al. (2002) and Tokuşoğlu et al. (2007). The samples were injected into a gas chromatography (QP 5050 GC/MS) fitted with a capillary column Cp WAX 52 (CB50m x 0.32 mm x 1.2 μm). The temperatures of the injection port and detector were 240^{o} C and 250° C, respectively. The oven temperature was 175° C for 27 min, followed by an increase to 215° C at a rate of 4° C/min and 5 min at 215° C and followed by an increase to 240°C at a rate of 4°C/min and 15 min at 240°C. The carrier gas was helium (10 psi). The fatty acids were expressed as percentages of the total fatty acid content.

Statistical analyses were performed using the SPSS v. 9.0 for Windows. Analysis of variance (one-way ANOVA) was used and statistical significance was set at P=0.05.

Results

Moisture, crude fat, crude protein and crude ash analysis were performed the food components of fresh sand smelt (F), chips dough (CD) and pre-fried fish chips (PF) samples. The results obtained are given on Table 1.

Table 1: Food components of fresh sand smelt, fish chips dough and pre-fried fish chips (%) [*]

Chips	*Moisture*	*Crude Fat*	*Crude Protein*	*Crude Ash*
F	79.533±0.213^{a}	2.047±0.052^{b}	16.420±0.380^{a}	2.030±0.129^{c}
CD	69.900±0.087^{b}	1.967±0.063^{b}	11.748±0.255^{b}	2.832±0.041^{b}
PF	66.243±0.456^{c}	5.243±0.371^{a}	11.691±0.320^{b}	3.220±0.137^{a}

[*] Means within the same column having different superscripts are significantly different at P<0.05.

Table 2: The changes in the fatty acid composition of the samples of pre-fried fish chips during the frozen storage (%)*

FA	F	CD	Pre-fried samples (month)						
			0	1	2	3	4	5	6
C 14:0	1.55±0.13a	0.73±0.07b	0.29±0.02c	0.34±0.00c	0.36±0.01c	0.32±0.02c	-	0.32±0.02c	0.35±0.02c
C 15:0	0.50±0.03a	0.43±0.02b	0.18±0.01c	-	-	-	-	-	-
C 16:0	24.70±0.67a	22.48±0.52a	17.54±0.74c	17.09±1.18c	16.79±0.70c	17.58±0.66c	16.80±0.50c	16.38±0.08cd	14.72±0.20d
C 16:1	8.51±0.27a	4.13±0.29b	1.47±0.10cd	1.78±0.08c	1.67±0.07cd	1.66±0.06cd	1.66±0.07cd	1.65±0.14cd	1.26±0.09d
C 17:0	0.75±0.00a	0.43±0.02b	0.24±0.02c	0.24±0.00c	0.25±0.00c	0.27±0.03c	-	0.26±0.01c	0.17±0.01d
C 18:0	6.62±0.43a	4.47±0.13c	4.99±0.10bc	5.66±0.64b	5.16±0.10bc	4.80±0.13c	4.50±0.02c	4.46±0.09c	4.58±0.09c
C 18:1 w-9	11.45±0.31d	14.33±0.69c	21.02±0.76b	21.58±1.39ab	22.50±0.61ab	20.91±0.74b	22.10±0.51ab	21.55±0.46ab	23.56±0.65a
C 18:1 w-7	5.71±0.07a	3.43±0.11b	2.15±0.05c	2.26±0.18c	2.10±0.06cd	2.08±0.05cd	1.61±0.30e	1.99±0.03cd	1.75±0.07de
C 18:2 w-6	3.25±0.15e	24.67±1.21d	37.66±0.85c	38.90±1.26bc	39.55±0.90bc	37.67±0.84c	41.05±0.75ab	40.48±0.82ab	42.70±0.35a
C 18:3 w-6	1.42±0.05b	3.28±0.36a	1.41±0.16b	1.51±0.22b	1.33±0.10b	1.43±0.06b	1.41±0.07b	1.37±0.10b	1.05±0.11b
C 20:0	0.68±0.01a	0.39±0.05b	0.23±0.07c	-	0.10±0.05de	0.11±0.05de	-	0.19±0.00cd	0.07±0.03e
C 22:6 w-3	13.52±0.83a	7.55±0.45b	5.34±0.61c	3.56±1.46c	4.70±0.20c	5.360±0.22c	4.96±0.34c	5.47±0.34c	4.44±0.12c
C 20:4 w-6	5.28±0.11a	2.99±0.02b	2.23±0.13c	2.09±0.258cd	1.92±0.28cd	2.29±0.15c	2.08±0.07cd	2.05±0.11cd	1.64±0.13d
C 20:5 w-3	8.82±0.03a	4.87±0.12b	2.81±0.10c	2.85±0.49c	2.86±0.40c	3.31±0.10c	3.24±0.24c	3.08±0.20c	2.59±0.21c
C 22:5 w-3	2.28±0.22a	1.26±0.12b	0.31±0.04cd	0.52±0.09c	0.24±0.03de	0.42±0.00cd	-	-	-

* Means within the same row having different superscripts are significantly different at P<0.05.

Table 3: The changes in the fatty acid composition of sun flower oil and pre-fried sun flower oil (%)*

	$C_{16:0}$	$C_{18:0}$	$C_{18:1\ \omega-9}$	$C_{18:2\ \omega-6}$
Sunflower oil before frying	5.987±0.067[a]	3.167±0.059[a]	33.327±0,289[a]	57.520±0.337[a]
Sunflower oil After frying	6.400±0,012[a]	3,207±0,006[a]	32.307±0.379[a]	57.087±0.384[a]

* Means within the same column having different superscripts are significantly different at P<0.05.

Table 4: The sensory evaluation of fish chips *

Chips (Month)	*Flavour*	*Texture*	*Color*	*Odour*	*General Acceptability*
0	8.067±0.228^{a}	8.133±0.165^{a}	8.200±0.223^{ab}	8.200±0.222^{a}	8.333±0.187^{a}
1	8.000±0.195^{a}	8.200±0.200^{a}	7.867±0.191^{ab}	8.267±0.153^{a}	8.267±0.118^{a}
2	8.067±0.182^{a}	8.200±0.175^{a}	8.533±0.192^{a}	8.333±0.187^{a}	8.200±0.107^{ab}
3	7.933±0.182^{a}	8.267±0.153^{a}	7.800±0.296^{ab}	8.267±0.182^{a}	8.200±0.175^{ab}
4	8.133±0.215^{a}	7.933±0.206^{ab}	7.667±0.252^{bc}	8.333±0.232^{a}	8.067±0.228^{ab}
5	8.000±0.195^{a}	8.133±0.192^{a}	8.000±0.309^{ab}	8.200±0.200^{a}	7.933±0.153^{ab}
6	7.667±0.232^{a}	7.333±0.347^{b}	7.000±0.293^{c}	8.067±0.228^{a}	7.667±0.287^{b}

*Means within the same column having different superscripts are significantly different at P<0.05.

The difference of moisture and crude ash and crude fat was significant (P<0.05) in the analysis performed by the samples of chips dough and pre-fried fish chips, and following the analysis carried out on crude protein, there was insignificant (P>0.05) difference between F and CD, respectively (Table 1).

As it is understood from the fatty acid analysis performed during the stages of fresh sand smelt and pre-fried fish chips production and during the period of storage for 6 months, an important increase was observed at the values of $C_{18:1\ \omega-9}$ and $C_{18:2\ \omega-6}$ with the pre-frying process. In addition, at the samples of pre-fried fish chips, important amounts of $C_{22:6\ \omega-3}$ and $C_{20:5\ \omega-3}$ which are both polyunsaturated (PUFA) fatty acids were measured (Table 2). The change in the fatty acid content in fried sun flower oil was found insignificant (P>0.05) (Table 3).As it is shown in Table 4, in the sensory evaluations made by panelists, there was a statistically significant (P<0.05) decrease from the initial level of general acceptability at the end of the 6 month storage period. The pH, TBA and TVB-N values of pre-fried fish chips at -18 ^{o}C during the period of storage are shown in Table 5.

While a regular increase was generally observed at TVB-N values of pre-fried fish chips samples under the conditions of deep freeze, an irregularity was determined at the values of pH and TBA (Table 5).

The change in the values of TMA, TPA, yeast - mould, and coliform of the sand smelts which had been processed as fish chips under the conditions of storage at -18 ^{o}C has been given in Table 6. Fecal coliform has not been determined.

Table 5: Some quality changes of pre-fried fish chips during frozen storage at -18 °C [*]

Chips	*pH*	*TVB-N(mg/100g)*	*TBA(µgMDA/g)*
F	6.520±0.012^{a}	17.140±0.289^{e}	0.330±0.020^{d}
CD	6.174±0.342^{b}	18.069±0.222^{de}	0.357±0.007^{cd}
0	6.644±0.002^{a}	19.749±0.589^{c}	0.373±0.003^{bcd}
1	6.628±0.008^{a}	19.413±0.147^{cd}	0.433±0.022^{ab}
2	6.629±0.006^{a}	20.420±0.144^{bc}	0.420±0.012^{abc}
3	6.727±0.017^{a}	21.513±0.083^{ab}	0.480±0.010^{a}
4	6.692±0.013^{a}	21.853±0.337^{ab}	0.390±0.056^{bcd}
5	6.718±0.009^{a}	21.847±0,083^{ab}	0.387±0.007^{bcd}
6	6.808±0.023^{a}	22.460±1.143^{a}	0.320±0.006^{d}

[*]Means within the same column having different superscripts are significantly different at P<0.05.

Table 6: The microbiological changes in the samples of pre-fried fish chips during at -18 °C (log cfu/g)[*]

Chips	*TMA*	*TPA*	*Yeast-Mould*	*Koliform*
F	5.785±0.008^{b}	5.637±0.035^{a}	0.888±0.269^{a}	1.484±0.007^{bc}
CD	5.983±0.008^{a}	5.479±0.058^{b}	0.991±0.088^{a}	1.379±0.018^{cd}
0	4.498±0.021^{e}	4.645±0.054^{c}	-	1.349±0.048^{cd}
1	4.968±0.014^{c}	3.900±0.055^{e}	-	1.188±0.042^{d}
2	4.732±0.016^{d}	4.691±0.058^{c}	-	1.476±0.029^{bc}
3	4.132±0.079^{f}	4.094±0.019^{d}	-	1.621±0.041^{b}
4	4.861±0.083^{c}	4.680±0.027^{c}	-	1.840±0.063^{a}
5	4.230±0.035^{f}	4.535±0.044^{c}	-	1.211±0.132^{d}
6	4.511±0.020^{e}	3.968±0.065^{de}	-	1.525±0.078^{bc}

[*]Means within the same column having different superscripts are significantly different at P<0.05.

Discussion

In a study, food components of *A.mochon* were determined that the fresh samples contain 71.9-73.1 % moisture, 19.0-20.4 % crude protein, 5.1-5.2 % crude fat and 2.4-2.6% crude ash(El-Sahn et al.,1990 and Kalogeropoulos et al., 2004). In their study on the subject of evaluating the chemical compositions of raw and fried *A. boyeri*, the moisture was found as 766.3 g/kg for fresh fish, 571.2 g/kg for fried in pan, the total amount of fat was found as 21.1 g/kg and 142.3 g/kg, respectively and the protein was found as 172.1 g/kg and 208.8 g/kg, respectively. These results generally show similarity with the results obtained from our studies (Table 1).

In a similar study, fish ball was produced from the boiled minced carp (*Cyprinus carpio*) and, 73.04 % moisture, 16.67 % crude protein, 8.45 % lipid and 1.18 % crude ash were determined in the fresh carp, 75.89 % moisture, 15.34 % crude protein, 6.98 % lipid and 1.09 % crude ash were found in the boiled minced fish (Yanar and Fenercioğlu, 1999). In our research, pre-frying procedure on fish chips decreased the ratio of moisture and crude protein (Table 1).

In a research for making fish balls from remains of pike-perch (*S.lucioperca*) and tench (*T. tinca*) fillets and determining shelf life, while the chemical composition of raw pike-perch was 80.18±0.79 % moisture, 15.25±0.09 % crude protein, 1.28±0.33 % crude fat and 2.02±0.11 % crude ash, it was changed to 72.40±1.32 % moisture, 11.83±1.49 % crude protein, 6.67±0.44 % crude fat and 2.53±0.65 % crude ash in fish ball prepared from pike-perch. In the same way, raw tench contained 83.41±1.10 % moisture, 12.68±1.19 % crude protein, 1.10±0.22 % crude fat and 1.66±0.36 % crude ash while in fish ball they changed as 71.69±0.79 % moisture, 10.26±1.49 % crude protein, 6.60±0.24 % crude fat and 4.15±0.43 % crude ash (Ünlüsayın et al., 2002). In a study carried out on fish burgers of deep flounder (*Pseudorhombus elevatus*) and brushtooth lizardfish (*Saurida undosquamis*), while the chemical composition of *P. elevatus* paste was determined as 77.23±0.04 % moisture, 19.48±0.18 % crude protein, 2.13±0.18 % total lipid and 1.37±0.1 % crude ash but those of fish burger was prepared from *P. elevatus* were changed to 65.58±0.46 % moisture, 19.01±0.23 % crude protein, 6.73±0.33 % total lipid and 2.71±0.07 % crude ash. Also, contents of *S. undosquamis* paste were 77.09±0.35 % moisture, 21.08±0.37 % crude protein, 1.62±0.18 % total lipid and 1.40±0.08 % crude ash, while in fish burger they changed to 67.55±0.39 % moisture, 18.69±0.19 % crude protein, 5.45±0.11 % total lipid and 2.87±0.06 % crude ash (Mahmoudzadeh et al., 2010). Also in our research, we determined a decrease in the values of moisture and crude protein in the fresh samples following processes, while an increase was observed in the amounts

of crude fat and crude ash after the pre-frying (Table 1). In a study, the most amount of fatty acids in the samples belonging to *A. boyeri* are SFA - $C_{16:0}$ as 27.1±3.2 %, in MUFA - $C_{18:1\ \omega-9}$ as 4.6±0.3 %, and in PUFA - $C_{22:6\ \omega-3}$ as 24.8 ±3.9 % (Tanakol et al., 1999). The findings of this study, which was carried out by the fresh samples of sand smelt, show similarity with our study. Kalogeropoulos et al. (2004) determined fatty acids compositions of the fried sand smelt with olive oil and found a decrease in $C_{22:6\ \omega-3}$ and an increase in $C_{18:1\ \omega-9}$. The results of our research are similar with the results of this research (Table 2).

Sehgal and Sehgal (2002) reported that, the general acceptability score of panelists for fish fingers prepared from carp were determined as 7.12. Mahmoudzadeh et al. (2010) reported that panelists got better taste from fish burgers of deep flounder more than that from lizardfish. Boran and Köse (2007) reported that general acceptability score of panelists for fish balls prepared from plain mince and surimi of whiting (*Merlangius merlangus euxinus*) shown its good quality. However, the pre-cooked fish balls had the best quality among all the fish balls samples. Those results of sensory analyses are almost the same as our results (Table 4). El-Sahn et al. (1990) detected that the pH level of sand smelt decreased from the level 6.1-6.2 to 5.9-5.8 with salting process. The pH level of fish chips were changed irregularly, but it was increased at the end of the storage period. It is thought that the difference that occurred can be caused by the different processing technology. Baygar et al. (2008) that reported pH values of raw rainbow trout and cooked group were determined as 6.29±0.01 and 6.33±0.01, respectively. Mahmoudzadeh et al. (2010), pH values of *P. elevatus* and *S. undosquamis* burgers were determined as 6.83±0.02 and 7.00±0.00, at the end of storage (-18 ^{o}C), respectively. In another study, the pH value of fish ball prepared from *Clarias gariepinus* without vacuum at the end of the storage period (-18 ^{o}C) was determined as 6.72±0.00 (Ersoy and Yılmaz, 2003). These results are almost parallel to our results (Table 5).

Ersoy and Yılmaz (2003) reported that TVB-N values of fish ball from *C.gariepinus* without vacuum increased during the storage period and were determined as 18.2±0.00 mg/100 g (at the end of the storage period). This is different from our results. These differences may be due to the initial values and the use of different species (Table 5).

Yanar and Fenercioğlu (1999) made minced fish meat from carp and reported TBA values at the beginning and end of 6 month storage period (-18 ^{o}C) as 0.6 and 2.2 mg MDA/kg, respectively. Whiting fishball with three different methods was done. The TBA value was 0.20 (0. day) and reached to 1.22 mg MDA/kg at the end of 15 day storage in pre-cooked fishball (Boran and Köse,

2007). Mahmoudzadeh et al. (2010) measured TBA values of deep flounder burger and lizardfish burger at the end of the 5 month storage (-18 ^{o}C) and found 0.22±0.02 mg MDA/kg and 0.26±0.01 mg MDA/kg, respectively. These results are almost parallel to our results (Table 5).

El-Sahn et al. (1990) reported that the total number of microorganisms after removing *A. mochon* head and internal organs decreases from $30x10^3$ cfu/g to $16x10^3$ cfu/g, The load on the whole fish after salting decreases from $30x10^3$ cfu/g to $8x10^3$ cfu/g and in the ones salted following removal of the head and internal organs, it decreases from $16x10^3$ cfu/g to $6.5x10^3$ cfu/g. Çaklı et al. (2005) made fish finger study on different species. At the beginning of the storage period (0^{th} month), *S. pilchardus* fish fingers contained 4.61 log cfu/g, *M. merlangus* fish fingers contained 4.62 log cfu/g and *S. lucioperca* fish fingers contained 4.50 log cfu/g aerobic microorganism, and at the end of the storage period (8^{th} month), the amount of microorganisms fell to 4.34 log cfu/g, 3.86 log cfu/g and 3.73 log cfu/g, respectively. In addition, at the beginning of the storage period (0^{th} month), they could have detected the coliform microorganisms, except for *S. lucioperca*. Mahmoudzadeh et al. (2010) reported that the burgers from *P. elevatus* and *S. undosquamis* had the reduced number of the microorganisms at the end of storage (-18 ^{o}C). According to the results of chemical, sensory and microbiological analysis, fish chips were found within the acceptable limits during frozen storage for 6 months at -18 ^{o}C. As it is also one of the first processing technologies for the species, we think this study is important. Furthermore, we think that a different taste can be gained by applying the technology of fish chips to sand smelt, enlarging the product range which is one of the objectives of processing technology; it can be done more economically.

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