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Full Length Research Paper

Production of fish finger from sand smelt (*Atherina boyeri*, RISSO 1810) and determination of quality changes

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In this study, changes of chemical, microbiological load and sensory properties of fish fingers prepared from sand smelt (*Atherina boyeri*, RISSO 1810) were investigated during storage (for 6 months at -18°C). The fish finger nutritional composition changed with the fish finger process. The changes in moisture, crude protein, crude fat and crude ash components between fresh sand smelt and fish fingers were found to be significant at P < 0.05. $C_{18:1\ \omega\text{-}9}$ and $C_{18:2\ \omega\text{-}6}$ increased with pre-frying process. The values of pH, total volatile basic nitrogen (TVB-N) and thiboarbutiric acid (TBA) at the end of the storage were determined as 6.737 ± 0.012, 19.583 ± 0.087 mg/100 g and 0.293 ± 0.013 µgMDA/g, respectively. According to sensory analyses scores, the fish fingers were fondly prefered by panellists. According to the results of the chemical, sensory and microbiological quality in fish, fish fingers were found within the acceptable limits during frozen storage for 6 months.

Key words: Sand smelt, *Atherine boyeri*, fish finger, chemical quality, sensory quality, fatty acids.

INTRODUCTION

Fish products are very important for human nutrition. Nowadays, as parallel to the increasing business tempo, the consumption of food as "heat and eat" has become important. Food sector has taken place amongst the most important sectors currently according to this way. Frozen technology is important for products preservation in long storage, in that it is used in seafood.

Several studies which have been done on fish fingers from different species, have determined the chemical composition, quality parameters, sensory evaluation and microbiological load (Sehgal and Sehgal, 2002; Çakli et al., 2005; Tokur et al., 2006). However, production of fish finger from sand smelt has not been found. There are some studies on different processing (freezing, frying and marinate, etc.) from sand smelt (Kalogeropoulos et al., 2004; Çolakoğlu et al., 2006; Çetinkaya, 2008).

Sand smelt (*Atherina boyeri*) is an uneconomical species in Turkey. The aim of this study was to produce fish fingers from sand smelt and to determine some chemical, sensorial and microbiological changes during storage at -18°C.

MATERIALS AND METHODS

Sample preparation

Fresh sand smelt was obtained from Eğirdir cooperative of fishery products, whereas fresh fish with ice in boxes were transported to the laboratory in thirty minutes. First of all, the heads and internal organs were thrown and their fillets were removed. After separating some of these fillets for analyzing their food component, the remaining parts were used for producing "fish finger". The fillets were minced with meat mincer and the fish fingers were made according to Çakli et al. (2005) and Tokur et al. (2006). For the fish finger, the mixture was provided by using 93.5% minced fish, 1.52% salt, 1% sugar, 3% wheat flour, 0.24% cumin, 0.24% onion powder, 0.24% garlic powder, 0.24% black paper and 0.02% thyme. Consequently, the mixture was formed after the compositions were mixed and after it became smooth. The batter and breading materials were obtained from Pinar Company (Izmir, Turkey). The batter was homogenized for 2 min (cold water/batter flour ratio of 2.2:1 w/w). After the batter application, it was covered with breading crumbs and then, it had been pre-fried in the sun flower oil which had the temperature of 180°C for 30 s and was later filtered. It was

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Table 1. Chemical composition of fresh sand smelt, fresh fish finger and pre-fried fish finger (%) (SE)*.

Parameter	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[b]
FF	66.287 ± 0.345[b]	1.893 ± 0.074[b]	14.150 ± 0.085[b]	2.323 ± 0.127[ab]
PF	59.427 ± 0.122[c]	9.807 ± 0.640[a]	13.003 ± 0.097[c]	2.625 ± 0.081[a]

*Means within the same column having different superscripts are significantly different at P < 0.05. F, raw sand smelt; FF, raw fish finger; PF, pre-fried fish finger.

quick-frozen at -80℃ and kept by using the plastic cases cover which was suitable to store at -18℃ for six months.

Analytical procedures

The nutritional component of the raw material and fish finger were performed on the production day. The chemical quality, sensory and microbiological analyses of fish fingers were determined during storage. 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) (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 micro-organism (TMA), total psicrophilic aerobic microorganism (TPA) and coliform number and yeast-mould number were determined (Anonymous, 1994; Arslan et al., 1997; ICMSF, 1978; Refai, 1979).

The sensory analysis of the fish finger provided was performed according to the method reported by Tokur et al. (2006) through flavour, texture, color, odor and general acceptability between 1 and 9 points at hedonic scale. Fish fingers were evaluated by experienced judges on each month of sampling. The panelists for flavour, texture, color, odour and general acceptability examined the samples. A value of 1 corresponded to the lowest and a value of 9 to the highest intensity for each parameter.

The pH analysis was carried out using WTW mark 320 sets digital pH meter which probe the performance that was measured 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 the 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 (CB 50 m x 0.32 mm x 1.2 µm). The temperatures of the injection port and detector were 240 and 250℃, respectively. The oven temperature was 175℃ for 27 min running time, followed by an increase to 215℃ at a rate of 4℃/min and 5 min at 215℃ and was followed by an increase to 240℃ at a The fatty acids were expressed as percantages of the total fatty acid content.

Statistical analysis

In the research, at evaluating the results benefiting from SPSS 9.0 windows program, the variance analysis in the P = 0.05 confidence interval (one-way ANOVA) was applied.

RESULTS

According to the results of the chemical composition analyses, moisture and crude protein contents decreased significantly (P < 0.05), crude fat increased significantly (P < 0.05) and crude ash contents of fish fingers with pre-frying increased insignificantly (P > 0.05) (Table 1).

According to the results of the fatty acid analysis, it was determined that there existed an important increase (P < 0.05) in $C_{18:1\ \omega\text{-}9}$ and $C_{18:2\ \omega\text{-}6}$ with pre-frying (Table 2). The fatty acid content in fried sun flower oil change was found to be insignificant (P > 0.05) (Table 3).

As it is seen in Table 4, in the evaluations made by panelists, it is seen that there is an important statistical decrease in all the parameters belonging the sensory evaluation at the end of the 6 month period of storage according to the initial value (P < 0.05). The pH, TBA and TVB-N values of fish finger were at -18℃ during the period of storage in Table 5.

While a regular increase was generally observed in pH (except for the 1st month) values of pre-fried fish finger samples on the conditions of deep freeze, an irregularity was determined at the values of TVB-N 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 the fish finger on the conditions of storage at -18℃ has been given in Table 6. However, fecal coliform were not found in the samples.

DISCUSSION

In many of the developed countries, the habits of nourishment are changing and a large potential is getting constituted for the fishery products like “heat and eat”. For troubles that occurred at the ready foods during preparation and odour decreased at the maximum level, different products processed by new techniques nowadays were developed and they were able to be marketed successfully.

Table 1 shows the chemical composition of fresh and fish finger samples. El-Sahn et al. (1990) examined *Atherina mochon* species, and determined that the fresh samples include 71.9 to 73.1% moisture, 19.0 to 20.4% crude protein, 5.1 to 5.2% crude fat and 2.4 to 2.6% crude ash. In the study performed by Kalogeropoulos et al. (2004) on the subject of evaluating the food and chemical compositions of the Mediterranean fish and shellfish fried in pan, moisture was found out as 766.3 g/kg in the fresh fish and 571.2 g/kg in the ones fried in pan, while the total amount of fat was found as 21.1 and

Table 2. The changes at the fatty acid composition of the samples of F, FF and PF during the storage (%) (SE) *.

Fatty acid	F	FF	0	1	2	3	4	5	6
$C_{14:0}$	1.553 ± 0.134^{a}	0.967 ± 0.030^{b}	0.237 ± 0.008^{cd}	0.220 ± 0.015^{d}	0.293±0.022^{cd}	0.377±0.054^{c}	0.320±0,000^{cd}	0,363 ± 0.017^{cd}	0.280 ± 0.000^{cd}
$C_{15:0}$	0.507 ± 0.035^{a}	0.220 ± 0.044^{b}	-	-	-	-	-	-	-
$C_{16:0}$	24.707 ± 0.676^{a}	24.520 ± 0.914^{a}	15.650 ± 0.635^{b}	16.107 ± 0.504^{b}	14.947 ± 0.248^{b}	15.473 ± 0.119^{b}	16.133 ± 0.589^{b}	14.570 ± 0.407^{b}	14.660 ± 0.257^{b}
$C_{16:1}$	8.513 ± 0.276^{a}	5.863 ± 0.267^{b}	1.183 ± 0.019^{c}	1.233 ± 0.074^{c}	1.273 ± 0.041^{c}	1.400 ± 0.045^{c}	1.503 ± 0.115^{c}	1.270 ± 0.101^{c}	1.097 ± 0.020^{c}
$C_{17:0}$	0.753 ± 0.006^{a}	0.603 ± 0.017^{b}	0.263 ± 0.015^{c}	0.182 ± 0.078^{c}	0.200 ± 0.012^{c}	0.253 ± 0.003^{c}	0.200 ± 0.012^{c}	0.253 ± 0.018^{c}	-
$C_{18:0}$	6.620 ± 0.439^{a}	5.963 ± 0.052^{b}	4.707 ± 0.084^{c}	5.190 ± 0.140^{c}	4.747 ± 0.081^{c}	4.930 ± 0.180^{c}	4.727 ± 0.131^{c}	4.813 ± 0.222^{c}	4.610 ± 0.116^{c}
$C_{18:1\ \omega\text{-}9}$	11.450 ± 0.310^{c}	13.093 ± 0.525^{c}	22.110 ± 0.525^{ab}	22.927 ± 0.739^{ab}	24.387 ± 0.672^{a}	22.283 ± 0.411^{ab}	23.180 ± 1.060^{ab}	23.817 ± 0.954^{ab}	23.340 ± 0.125^{ab}
$C_{18:1\ \omega\text{-}7}$	5.710 ± 0.078^{a}	4.820 ± 0.357^{b}	1.897 ± 0.013^{c}	1.947 ± 0.091^{c}	1.810 ± 0.038^{c}	2.043 ± 0.088^{c}	1.940 ± 0.100^{c}	1.867 ± 0.145^{c}	1.717 ± 0.040^{c}
$C_{18:2\ \omega\text{-}6}$	3.253 ± 0.151^{e}	16.493 ± 0.159^{d}	42.357 ± 0.312^{b}	41.610 ± 1.143^{b}	42.223 ± 0.507^{b}	38.517 ± 0.757^{c}	38.503 ± 0.536^{c}	40.837 ± 1.133^{b}	44.763 ± 0.492^{a}
$C_{18:3\ \omega\text{-}6}$	1.427 ± 0.059^{b}	1.903 ± 0.041^{a}	0.900 ± 0.005^{cd}	0.763 ± 0.023^{ef}	0.713 ± 0.038^{f}	0.863 ± 0.043^{cde}	0.977 ± 0.062^{c}	0.690 ± 0.081^{f}	0.803 ± 0.027^{def}
$C_{20:0}$	0.683 ± 0.017^{a}	0.463 ± 0.013^{b}	0.147 ± 0.003^{cd}	0.160 ± 0.015^{cd}	-	0.140 ± 0.021^{cd}	0.177 ± 0.015^{c}	0.127 ± 0.017^{d}	-
$C_{22:6\ \omega\text{-}3}$	13.523 ± 0.838^{a}	9.580 ± 0.622^{cd}	4.863 ± 0.382^{cd}	5.173 ± 0.529^{cd}	3.957 ± 0.183^{d}	5.427± 0.298^{c}	4.150 ± 0.470^{cd}	4.507± 0.235^{cd}	4.383±0.470^{cd}
$C_{20:4\ \omega\text{-}6}$	5.283 ±0.112^{a}	4.413 ± 0.319^{b}	1.843 ± 0.047^{c}	1.767 ± 0.295^{c}	1.773 ± 0.182^{c}	2.360 ± 0.038^{c}	1.883 ± 0.226^{c}	1.750 ± 0.288^{c}	1.780±0.067^{c}
$C_{20:5\ \omega\text{-}3}$	8.823 ± 0.032^{a}	7.053 ± 0.485^{b}	2.833 ± 0.039^{cd}	2.420 ± 0.338^{d}	2.463 ± 0.274^{d}	3.513 ± 0.035^{c}	2.687± 0.270^{d}	2.740 ± 0.311^{d}	2.583±0.073^{d}
$C_{22:5\ \omega\text{-}3}$	2.280 ± 0.220^{a}	1.863 ± 0.043^{b}	0.677 ± 0.142^{c}	-	-	0.663 ± 0.064^{c}	0.597± 0.026^{c}	0.800 ± 0.000^{c}	-

*Means within the same row having different superscripts are significantly different at $P < 0.05$. F, raw sand smelt; FF, raw fish finger; PF, pre-fried fish finger.

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

Parameter	$C_{16:0}$	$C_{18:0}$	$C_{18:1\ \omega\text{-}9}$	$C_{18:2\ \omega\text{-}6}$
Sun flower oil	5.987 ± 0.067^{a}	3.167±0.059^{a}	33.327 ± 0.289^{a}	57.520 ± 0.337^{a}
Fried sun flower oil	6.250 ± 0.226^{a}	3.073 ± 0.096^{a}	32.313 ± 0.313^{a}	58.363 ± 0.270^{a}

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

142.3 g/kg, and the protein as 172.1 and 208.8 g/kg, respectively. In a research at which the species of *Sardina pilchardus*, *Merlangius merlangus* and *Sander lucioperca* were used for producing fish finger, it was determined that fresh fish included 64.47 ± 3.70%, 82.10 ± 0.25% and 82.00 ± 0.36% moisture, 18.70 ± 0.83%, 0.98 ± 0.07% and 0.68 ± 0.12% crude fat, 16.04 ± 0.27%, 15.26 ± 0.39% and 16.36± 0.21% crude protein and 1.20 ± 0.00%, 0.93 ± 0.31% and 2.00 ± 0.35% crude ash, respectively, while in fish fingers, it showed changes as 52.04 ± 0.82%, 63.01 ± 0.76% and 69.73 ± 3.66% moisture, 14.39 ± 0.90%, 6.71 ± 0.66% and 4.28 ± 0.17% crude fat, 16.16 ± 0.50%, 15.98 ± 0.51% and 15.75 ±

Table 4. The sensory quality changes of fried fish finger during storage -18°C (SE) *.

Finger (month)	Flavour	Texture	Color	Odour	General acceptability
0	8.533 ± 0.165[a]	8.533 ± 0.192[a]	8.867 ± 0.133[a]	8.533 ± 0.165[a]	8.667 ± 0.126[a]
1	8.733 ± 0.182[a]	8.733 ± 0.118[a]	8.867 ± 0.091[a]	8.733 ± 0.118[a]	8.800 ± 0.107[a]
2	8.867 ± 0.091[a]	8.733 ± 0.118[a]	8.667 ± 0.126[a]	8.667 ± 0.126[a]	8.667 ± 0.126[a]
3	8.600 ± 0.163[a]	8.600 ± 0.190[a]	8.667 ± 0.159[a]	8.867 ± 0.126[a]	8.600 ± 0.190[a]
4	8.467 ± 0.192[a]	8.667 ± 0.159[a]	8.600 ± 0.190[a]	8.600 ± 0.131[a]	8.667 ± 0.126[a]
5	8.533 ± 0.133[a]	8.267 ± 0.206[ab]	8.467 ± 0.165[a]	8.467 ± 0.133[a]	8.533 ± 0.133[a]
6	7.533 ± 0.389[b]	7.867 ± 0.274[b]	7.600 ± 0.306[b]	7.600 ± 0.400[b]	7.733 ± 0.345[b]

*Means within the same column having different superscripts are significantly different at P < 0.05. PF, pre-fried fish finger.

Table 5. pH, TBA and TVB-N changes of pre-frying fish finger at -18°C on the conditions of storage (SE) *.

Parameter	pH	TVB-N (mg/100 g)	TBA (µgMDA/g)
F	6.520 ± 0.012[bc]	17.140 ± 0.289[f]	0.330 ± 0.020[a]
FF	6.410 ± 0.006[d]	18.070 ± 0.223[de]	0.243 ± 0.019[de]
0	6.497 ± 0.072[bc]	19.247 ± 0.689[cd]	0.283 ± 0.003[bc]
1	6.453 ± 0.003[cd]	19.330 ± 0.223[cd]	0.213 ± 0.003[e]
2	6.523 ± 0.003[bc]	20.150 ± 0.306[bc]	0.250 ± 0.015[cd]
3	6.560 ± 0.006[b]	21.093 ± 0.443[b]	0.317 ± 0.003[ab]
4	6.700 ± 0.010[a]	23.783 ± 0.927[a]	0.323 ± 0.003[a]
5	6.720 ± 0.011[a]	21.517 ± 0.467[b]	0.297 ± 0.003[ab]
6	6.737 ± 0.012[a]	19.583 ± 0.087[cd]	0.293 ± 0.013[ab]

*Means within the same column having different superscripts are significantly different at P < 0.05. F, raw sand smelt; FF, raw fish finger; PF, pre-fried fish finger.

Table 6. The microbiological changes in the samples at -18°C (log cfu/g)*.

Parameter	TMA	TPA	Yeast-mould	Coliform
F	5.785 ± 0.008[b]	5.637 ± 0.035[b]	0.888 ± 0.269[a]	1.484 ± 0.007[b]
FF	5.998 ± 0.003[a]	5.973 ± 0.010[a]	0.989 ± 0.121[a]	1.914 ± 0.069[a]
0	4.808 ± 0.136[cd]	3.923 ± 0.078[e]	-	-
1	4.977 ± 0.023[c]	3.734 ± 0.044[f]	-	-
2	4.605 ± 0.049[e]	3.528 ± 0.051[g]	-	-
3	4.874 ± 0.029[c]	3.952 ± 0.049[de]	-	-
4	4.650 ± 0.048[de]	3.707 ± 0.064[f]	-	-
5	4.273 ± 0.048[f]	4.109 ± 0.053[d]	-	-
6	4.658 ± 0.005[de]	4.283 ± 0.063[c]	-	-

*Means within the same column having different superscripts are significantly different at P < 0.05. F, raw sand smelt; FF, raw fish finger; PF, pre-fried fish finger.

0.21% crude protein, and 2.61 ± 0.36%, 3.33 ± 0.80% and 2.75 ± 0.51% crude ash, respectively (Çakli et al., 2005). In this study, it was observed that there exists decrease in the ratio of moisture by the production of fish finger, an increase at the ratio of crude fat (excluding *S. pilchardus*), a very little increase at the ratio of crude protein (excluding *S. lucioperca*) and an increase in the content of crude ash in all the species mentioned according to the value at the beginning. These results generally show similarity with the results obtained from this studies (Table 1).

In the research by Tokur et al. (2006), they examined the quality criterion and produced fish finger from the carps captured from Seyhan Dam Lake, during their storage at -18°C. They determined 68.50% moisture in the fish fingers provided from the minced fish unwashed, 15.5% crude protein, 6.00% lipid and 2.20% crude ash and they determined 70.23% moisture in the fish fingers provided from the minced fish washed, 10.8% crude protein, 2.14% lipid and 1.80% crude ash. As such, the results support our findings (Table 1).

The fatty acid analysis of fresh sand smelt and the entire fish finger (raw and pre-fried) samples was carried out. According to the results of fatty acid analysis, it was determined that there existed a significant amount of increase ($P < 0.05$) in oleic acid and linoleic acid in the pre-fried samples and an important amount of decrease in the other fatty acids. It was determined that, palmitic acid ($C_{16:0}$) had the highest ratio within the saturated fatty acids (SFA) and oleic acid ($C_{18:1\ \omega-9}$) had the highest within the monounsaturated fatty acids (MUFA). In the polyunsaturated fatty acids (PUFA), it was determined that decosahexaenoic acid ($C_{22:6\ \omega-3}$) is in the fresh samples and linoleic acid ($C_{18:2\ \omega-6}$) at the samples of fish finger on which pre-fried procedure was performed (Table 2).

In a study conducted on fish species, the fatty acid compositions of some fish species which were caught from Marmara and Black seas, belonging to *A. boyeri,* in SFA - $C_{16:0}$ at 27.1±3.2%, in MUFA - $C_{18:1\ \omega-9}$ at 4.6±0.3%, and in PUFA - $C_{22:6\ \omega-3}$ at 24.8 ± 3.9 are the fatty acids which exist the most (Tanakol et al., 1999). The findings of this study, carried out by the fresh samples of sand smelt, show parallelism with the results which belongs to the fresh samples of this study (Table 2).

Tokur et al. (2006), making an application of fish finger from carp, evaluated the fatty acids composition, and determined that $C_{18:2\ \omega-6}$ fatty acid increased in the samples of fish finger made by both unwashed and washed minced fish by the procedure of pre-frying. In this study, it has been determined that $C_{18:2\ \omega-6}$ increased from 16.493 ± 0.159 to 42.357 ± 0.312% by the application of pre-frying at the samples of fish finger (Table 2).

In a research at which fatty acids composition was also determined after frying the fish, belonging to the Mediterranean Sea with olive oil, it was determined that $C_{22:6\ \omega-3}$ decreased after it was fried, but $C_{18:1\ \omega-9}$ increased (Kalogeropoulos et al., 2004). However, the results of our research are similar to that of this research (Table 2). According to the result of the overall sensory evaluation of fish finger, sand smelt fish finger was of good quality during the storage period of 6 months. Sehgal and Sehgal (2002) had prepared the ready meal technology from carps, and it was indicated that carps were suitable in the evaluation of fish finger. In a study, fish finger was produced from sardine, whiting and pike-perch. It was reported that fingers from whiting and pike-perch maintained their consumable at the end of storage according to sensory evaluation (Çakli et al., 2005). As it is understood through the sensory data we obtained, it is seen that the fish finger produced from sand smelt was liked by the panelists (Table 4).

The fish fingers from two different kinds of minced carp maintained the quality during 5 months of storage at -18 °C according to sensory evaluation (Tokur et al., 2006). It was detected that the fish fingers which were stored for 6 months, maintained their quality, so the results of Tokur et al. (2006) and this results are in accordance with our results (Table 4). The 6.520 ± 0.012 pH level of fresh sand smelt was found as 6.737 ± 0.012 in fish fingers at the end of the storage, and this difference was significant ($P<0.05$) (Table 5). Tokur et al. (2006) explained that, the pH values showed a wavy progress for both fish fingers samples. In this study, carp fingers produced from unwashed and washed mince at the end of the storage, were determined as 6.74 ± 0.00 and 6.67 ± 0.06, respectively. In the fish balls produced from the remaining pike-perch and tench, the pH increased at the end of the storage period at 4±1°C according to the initial value (Ünlüsayin et al., 2002). The results are almost similar with our results (Table 5).

The initial TVB-N value was determined as 17.140 ± 0.289 mg/100 g and it was determined that it generally increased depending on the fish finger and storage (Table 5). Akkuş et al. (2004) stored the fish balls that they had made from the raw and boiled fish meat at 4±1°C for 18 days, and they reported that it increased even if fluctuations were seen at TVB-N value during the storage. At the fish balls produced from the remainder of the pike-perch and tench fillet, TVB-N value increased at 4±1°C at the end of the storage period according to the initial value (Ünlüsayın et al., 2002). The results support that of our findings (Table 5).

The TBA value of fish finger from sand smelt reached 0.293 ± 0.013 µgMDA/g at the end of the sixth month (Table 5). Tokur et al.(2006) reported that, the fish fingers from both the unwashed and washed carp minced reached 0.27 ± 0.03 and 0.25 ± 0.02 mg MDA/kg, respectively These results similar to our TBA results.

Table 6 shows the microbiological changes of the fish fingers during the storage period. No fecal coliform bacteria were detected in fish fingers. The other microbiological groups were not high in value at the end of the storage period (Table 6). El-Sahn et al. (1990) determined that the total number of microorganism, removing *A. mochon* head and internal organs, decreased from $30x10^3$ to $16x10^3$ cfu/g while the load on the entire fish decreased from $30x10^3$ to $8x10^3$ cfu/g by getting salted. Moreover, the ones salted by removing the head and internal organs decreased to $16x10^3$ cfu/g. Çakli et al. (2005) determined total aerobic microrganism as 4.61 log cfu/g for sardine fingers, 4.62 log cfu/g for whiting fingers, 4.50 log cfu/g for pike perch fingers at the beginning of storage, and as 4.34 log cfu/g, 3.86 log cfu/g and 3.73 log cfu/g at the end of storage, respectively. In addition, they could not detect the coliform and fecal coliform microorganisms at the end of the storage. Tokur et al. (2006) reported that the fish fingers produced from unwashed minced fish and washed minced fish could not be found coliform. Also, they point out that total bacteria counts did not exceed limit, which were determined by The International Commission Specifications for food. Çolakoğlu et al. (2004) reported that the total bacteria numbers of fish balls produced from *Rutilus rutilus* and *Coregenus* sp were decreased with the frying process. Generally, it shows similarity with our results (Table 6).

Conclusions

One of the main aims of processing technology is to develop different tastes. Therefore, we think that a different taste of fish finger produced from sand smelt and these new flavours will increase the economic value of this species. According to this study results, it has been determined that the fish fingers produced from sand smelt maintained their consumable at the end of storage at -18 °C for 6 months.

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REFERENCES

Akkuş Ö, Varlık C, Erkan N, Mol S (2004). Determination of Some Quality Parameters of Fishballs Prepared from Raw and Boiled Fish. Turk. J. Vet. Anim. Sci. 28: 79-85.

Anonymous (1994). Merck Microbiology Manual, Published by Merck, Germany.

AOAC (2000). Official methods of analysis. 17th ed., Association official analytical chemists, Gaithersburg, Maryland.

Arslan A, Çelik C, Gönülalan Z, Ateş G, Kök A, Kaya A (1997). Analysis of Microbiological and Chemical Qualities of Vacuumed and Unvacuumed Mirror carp (*Cyprinus carpino* L.) Pastrami, Turk. J. Vet. Anim. Sci. 21: 23-29.

Çakli S, Taşkaya L, Kisla D, Çelik U, Ataman CA, Cadun A, Kilinc B, Maleki RH (2005). Production and quality of fish finger from different fish species. Eur. Food Res. Technol. 220: 526-530.

Çetinkaya S (2008). Some nutritional characteristics and marinate production from sand smelt (*Atherına boyerı,* RISSO 1810) catched from Egirdir Lake, Isparta, Turkey.

Çolakoğlu FA (2004). The effect of processing techniques on microflora of roach (*Rutilus rutilus*) and whitefish (*Coregenus sp.*). Turk J. Vet. Anim. Sci., 28: 239-247.

Çolakoğlu FA, Ova G, Köseoğlu B (2006). Microbiological quality of fresh and processed silver fish (*Atherina boyeri,* Risso 1810). E.U. J. Fish. Aquat. Sci. 23(1-3): 393-395.

El-Sahn MA, Youssef AM, Moharram YG (1990). Edible Products From Pelagic Bissaria (*Atherina mochon*) Fish Nahrung, 34(1): 47-52.

Erkan N, Özden Ö (2008). Quality assessment of whole and gutted sardines (*Sardina pilchardus*) stored in ıce. Int. J. Food Sci. Technol. 43: 1549-1559.

ICMSF (1978). Microorganism in Food 1, Their Significance and Methods of Enumeration, Second Edition, University of Toronto Press, ISBN: 0-8020-2293-6, Toronto.

Izquierdo N, Aguirrezábal L, Andrade F, Pereyra V (2002). Night Temperature Affect Fatty Acid Composition in Sunflower Oil Depending on the Hybrid and the Phenological Stage. Field Crops Res. 77: 115-126.

Kalogeropoulos N, Andrikopoulos NK, Hassapidou M (2004). Dietary evaluation of Mediterranean fish and molluscs pan-fried in virgin olive oil, J. Sci. Food Agriculture, 84: 1750-1758.

Lovell RT (1975). Laboratory Manual for Fish Feed Analysis and Fish Nutrition Studies, Auburn University Department of Fisheries and Allied Aquacultures, International Center for Aquaculture, Alabama.

Lovell RT (1981). Laboratory Manuel for Fish Feed Analysis and Fish Nutrition Studies. Auburn University Department of Fisheries and Allied Aquacultures, International Center for Aquaculture, Alabama.

Nicholas TA (2003). Antimicrobial use of native and enzymatically degraded chitosans for seafood aplications. The University of Maine, The Graduate School, Master Thesis, Maine, USA.

Refai MK (1979). Manual of Food Quality Control, 4. Microbiol. Anal. Food Agric. Organization of the United Nation, Rome.

Sehgal HS, Sehgal GK (2002). Aquacultural and Socio-economic Aspects of Processing Carps into Some Value-added Products. Biores. Technol. 82: 291-293.

Tanakol R, Yazıcı Z, Şener E, Sencer E (1999). Fatty Acid Composition of 19 Species of Fish from the Black Sea and the Marmara Sea. Lipids, 34(3): 291-297.

Tokur B, Özkütük S, Atıcı E, Özyurt G, Özyurt CE (2006). Chemical and Sensory Quality Changes of Fish Fingers, Made From Mirror Carp (*Cyprinus carpio* L., 1758), During Frozen Storage (-18 ºC). Food Chem. 99: 335-341.

Tokuşoğlu Ö, Durucasu İ, Akalın AS, Serin E, Akşıt S (2007). Fatty Acid and Conjugated Linoleic Acid Profiles of Infant Formulas Through Direct Transesterification of Acyl Lipids. Italian J. Food Sci. 19(4): 477-484.

Ünlüsayın M, Bilgin Ş, İzci L, Gülyavuz H (2002). The Preparation of Fish Ball from Pike Perch (*Sander lucioperca* L. Kottelat, 1997) and Tench (*Tinca tinca* L.1758)Filet Cracks and Determination of Shelf Life. J. Sci. Inst. 6(3): 25-34.