Scientific Research and Essays Vol. 6(31), pp. 6448-6453, 16 December, 2011
Available online at http://www.academicjournals.org/SRE
DOI: 10.5897/SRE11.769
ISSN 1992-2248 ©2011 Academic Journals

Full Length Research Paper

Determination of the fundamental nutritional components in fresh and hot smoked spiny eel (*Mastacembelus mastacembelus*, Bank and Solander, 1794)

İlkan Ali OLGUNOĞLU

Aquaculture and Fisheries Program, Kahta Vocational Training School, Adiyaman University, 02400 Kahta-Adiyaman, Turkey. E-mail: ilkanali@yahoo.com, iolgunoglu@adiyaman.edu.tr. Tel: +90 416 725 81 50.

Accepted 22 November, 2011

In this study the nutritional components of spiny eel obtained from Atatürk Dam Lake within the borders of Turkey by using fishing nets was investigated when it was fresh and after smoking process. While the quantity of the raw protein, raw fat, raw ash and carbohydrates in fresh spiny eel were determined as 19.88 ± 0.18%, 2.10 ± 0.62, 1.38 ± 0.24%, 0.07 ± 0.01%, respectively, it was ascertained that accounts were 36.69 ± 1.15%, 4.8 ± 0.28%, 13.76 ± 1.86%, 0.1 ± 0.01%, respectively after the hot smoking process and the changes were observed to be important (p<0.05). In the study, it was concluded that spiny eel was a crucial species meeting individual needs in terms of mineral substances such as Zn and Cu, beside being a good source of Fe. It was determined that it was poor in vitamin A, while it was rich in vitamin E as well. Besides, in the study, it was seen that thermal process applied during cooking and smoking had an effect of decreasing the quantity of essential fatty acids particularly such as EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid). Along with this, considering that the fat content of materials, which would be used in smoking process and which was the main criteria for smoking technology, it was concluded that hot smoking process was not a suitable method for spiny eel that contains low fat and that it could be utilized by using alternative process methods.

Key words: *Mastacembelus mastacembelus*, spiny eel, hot smoking, nutritional components.

INTRODUCTION

The spiny eel of the Mastacembelidae family used in the research is called the spiny eel because of the fact that it does not have ventral fins; that their body shape is like eels' and so are the prickles in its back as well. The width of its mouth and gill is relatively small and the space of the gill is in the back part of the throat. There are sharp prickles in front of the dorsal gill and they can be erected and kept flat anytime. Covered with a hard skin, thier bodies does not have scales. They have got two plorik extensions and a simple one lobed air saccule. Only *Mastacembelus mastacembelus* species of the Mastacembelus genus of Mastacembelidae family live in East and South-East Anatolian Regions of Turkey and they usually spread in the fresh and other waters of tropical Africa, Tigris-Euphrates parts and South and South-East parts of Asia (Şahinöz et al., 2006; Çakmak, 2008). As fisheries products deteriorate easily, they are exposed to processes so as to have a longer life in shelves in markets, to provide them with different taste; thus, to increase consuming amount and variety (Ayas, 2006). One of the technological processes applied to fisheries products is exposing them to smoke. Smoking technology and consuming smoked products is commonplace in Japan and other far-east countries, Canada, European Union countries and in Scandinavian countries (Bilgin et al., 2007). There have been many researches on spiny eel and smoking technology in different fish species in the world and in Turkey

(Aminullah et al., 1993; Kolsarici and Özkaya, 1998; Indrasena et al., 2000; Bilgin et al., 2001, 2007, 2008; Cardinal et al., 2001, 2004; Kiliç, 2002; Dondero et al., 2004; Eroğlu, 2004; Goulas and Kontominas, 2005; Pizara et al., 2005; Vasiliadou et al., 2005; Angiş et al., 2006a, b; Ayas, 2006; Kaya et al., 2006, 2008; Patir and Duman, 2006; Oğuzhan et al., 2006; Salan et al., 2006; Duman and Patir, 2007; Günlü, 2007; Şahinöz et al., 2007; Korkut, 2008; Şengör et al., 2008; Gümüş et al., 2010); but the literature research in the area does not show any clues of processing the spiny eel (*M. mastacembelus* Bank and Solander, 1794). This study is important in terms of offering the spiny eel which is in the potential production area of the Atatürk Dam Lake within the borders of Turkey to the consumers with a different aroma by being smoked and earning the nourishment statistics of the spiny eel to the literatures for the nourishment of human-being. This study is also important because it will be a model to the search of the nourishment quality of other fish species in the South-East Anatolian Region of Turkey and the research of the alternative processes to be applied. On the other hand, spiny eel is not consumed much by people in Turkey as it looks like serpent (Güven et al., 2002). Besides, consuming smoked product is rare in Turkey.

Fish, either acquired from seas or obtained by aquaculture, are all but consumed fresh. This springs out from the fact that traditional consuming habits are not left quickly and that it is not known how some species will be offered to consuming (Angiş et al., 2006a; Bilgin et al., 2006). With this study having been carried out, it is aimed to save consuming of the spiny eel from being monotonous and generalizing it to cover many sections. In fact, it can be thought that there can be an increase in the production of the over-mentioned species by presenting a potential choice for the fish beeing aquacultured depending on the consume that may increase in the future in the sector of fishery products aquaculturing in our country.

MATERIALS AND METHODS

Samples of spiny eel (*M. mastacembelus*) used as a material in the study were obtained from Ataturk Dam Lake in the borders of Turkey (37℃ 45 N' latitude/38℃ 17 E' longitude) by using fishing nets. In this study, thirty fish whose average weight was 254.68 ± 6.11 g were used. Samples were carried to Adiyaman University Kahta Vocational Training School Practice Laboratory, where smoking out was done, protecting with ice in a freezer just after the prey.

Samples brought to the laboratory were primarily classified according to their height and weight and then their stomach were cut off from anus to gill. After their inner organs, gills and renal histo were subtracted and washed, souse operation started. Souse of the eels which have thick skins and whose skins were not taken was done using table salt in proportion as 1:1 in 20% salt concentration.

After the washing and filtrating the samples which were kept in this wise in fridge (+4˚C) for 12 h, with the aim to take the salt and dirtiness accumulated on their surface, the smoking out was done by adopting the hot smoking method applied in Europan eels (*Anguilla anguilla*). Until this part of the process, after drying up the samples put into smoking cupboards, cooking operation which lasted 30 min at 90℃ was carried out and then at this heat, smoking out operation was applied (Varlik et al., 2004). After the smoking process the fish were left to room temperature to get cool and then they were shock-iced in -40℃, put in special boxes to be taken to the research labaratory. The tiny sawdust of oak tree was used in the smoking process. The average raw protein, raw fat, moisture, raw ash, carbohydrade, energy, vitamins (A,E), Cu, Zn and Fe amounts and fat acids of the smoked edible fresh fish meat analysis were carried out in TUBITAK-MAM (Turkish Scientific and Technologic Research Instutition-Marmara Search Center) laboratory. The raw protein analysis was carried out according to the Kjeldahl method; raw fat analysis was carried out according to the acid hydrolysis soxhlet system, moisture analysis was carried out by providing the samples dry in the sterilizer until they had come to a certain weight with homogeneoused samples; the raw ash analysis was carried out by burning the samples in 550℃ (AOAC) (1995). The carbohydrade and energy calculation of the samples were carried out with Watt and Merrill (1975) method; analysis of vitamins A and E were carried out by HPLC method (AOAC) (2000).

Cu, Zn and Fe's calculation were carried out by atomic absorbtion spectrofotometric (AAS) method (AOAC) (2005). Lipids methyl esters of fatty acids of samples were prepared according to IUPAC II. D. 19. (1979) method and the analysises were held by using Elmer Autosystem XL Gas Cromotograph and flame ionization detector (FID). In determining the fatty acids' composition, Supelco 2330 Fused Silica Column (30 mm × 0.25 mm × 0.20 µm film thickness) was used and the following conditions were provided:

Sample working conditions in gas cromatograph machine

Column oven conditions: waiting 2 min in 120℃ degre es, with 15℃ increase 10 min in 220℃.
Whole analysis: 32 min.
Injector heat: 240℃.
Carrying gas: 0.5 ml/min He.
Detector heat: 260℃.
Proportion: 1.
H_2: 45 ml/min.
Sample injection capacity: 2 µl.
Maximum column heat: 280℃.
Split currency: 50 ml/min.

The results of the research were exposed to SPSS 13.0 packet program for Windows group comparing test (t test) and they were given their standard ± deviation (Oğuzhan et al., 2006).

RESULTS

The main nutritional components of fresh and hot smoked spiny eel and the amount of minerals such as Cu, Zn, Fe and vitamins (A and E), which are important for human nourishment were given in Table 1. As seen in Table 1, the values of raw protein, raw fat and energy of hot smoked spiny eel were significantly higher ($p<0.05$) than the fresh spiny eel. Similar increases were found in vitamins A, E and mineral substance such as Fe. The

Table 1. The quantity of the fundamental nutritional composition, vitamin and mineral contens in fresh and hot smoked spiny eel (*M. mastacembelus*).

Food components	Fresh spiny eel	Hot smoked spiny eel
Protein (g/100 g)	19.88±0.18[a]	36.69±1.15[b]
Fat (g/100 g)	2.10±0.62[a]	4.80±0.28[b]
Moisture (g/100 g)	76.57±1.66[a]	44.65±1.05[b]
Ash (g/100 g)	1.38±0.24[a]	13.76±1.86[b]
Carbohydrate (g/100 g)	0.07±0.01[a]	0.10±0.01[b]
Energy (Kcal/100 g)	99[a]	190[b]
Vitamin A (mg/100 g)	0.04±0.01[a]	0.15±0.01[b]
Vitamin E (mg/100 g)	0.39±0.01[a]	2.37±0.26[b]
Cu (mg/100 g)	0.98±0.01[a]	0.12±0.01[b]
Zn (mg/100 g)	4.60±0.94[a]	2.44±0.38[b]
Fe (mg/100 g)	1.26±0.22[a]	2.71±0.60[b]

The values in the same row having the same superscript are significantly different ($p<0.05$). Values are shown as means ± SD of triplicate measurements.

Table 2. Fatty acid composition (%) of fresh and hot smoked spiny eel (*M. mastacembelus)*.

Fatty acid	Fresh spiny eel	Hot smoked spiny eel
C14:0	3.34±0.01[a]	3.72±0.05[b]
C 14:1	0.16±0.01[a]	n.d
C15:0	0.55±0.01[a]	0.75±0.01[b]
C16:0	18.98±0.10[a]	25.52±0.06[b]
C16:1	9.69±0.02[a]	10.18±0.03[b]
C17:0	0.69±0.01[a]	0.81±0.00[b]
C18:0	2.93±0.02[a]	4.23±0.07[b]
C18:1	17.12±0.04[a]	21.14±0.02[b]
C18:2 n-6	3.47±0.01[a]	3.56±0.03[b]
C18:3 n-6	0.14±0.01[a]	0.21±0.00[b]
C18:3 n-3	2.65±0.00[a]	1.96±0.10[b]
C20:0	0.14±0.01[a]	0.21±0.00[a]
C20:1	1.48±0.04[a]	1.65±0.06[b]
C20:2	0.46±0.01[a]	0.35±0.01[b]
C20:3 n-3	0.23±0.01[a]	0.15±0.03[b]
C20:5 n-3 (EPA)	1.76±0.01[a]	0.73±0.03[b]
C22:2	3.15±0.02[a]	1.91±0.05[b]
C22:6 n-3 (DHA)	9.36±0.02[a]	4.69±0.00[b]
C 24:1	n.d	0.40±0.01[b]
∑SFA	26.63	35.24
∑MUFA	28.45	33.37
∑ PUFA	21.22	13.56
Unknown	23.70	17.83

The values in the same row having the same superscript are significantly different ($p<0.05$). Values are shown as means ± SD of triplicate measurements, n.d: not detected.

amount of fatty acids were given in Table 2. As seen in Table 2, the highest total PUFA level were detected in fresh spiny eel, whereas the highest total SFA and MUFA were detected in hot smoked spiny eel.

DISCUSSION

The amount of protein of the raw spiny eel seems to be quite good when compared to some fisheries products whose protein statistics are between 11 to 25% (Varlik et al., 2004). Spiny eel can be put in the fat free fish group with its fat proportion which is less than 4% (Varlik et al., 2004); and that it has a low energy level (2.10% raw fat; 99 kcal/100 g energy). However, it has been found out that the hot smoking process is not an appropriate method for the spiny eel fish as the fat proportion of the fisheries products are expected to be over 5% (Varlik et al., 2004). It has been found out that the moisture proportion of spiny eel fish has decreased to 44.65 ± 1.05% due to the water loss after hot smoking process; while percentage raw protein, percentage raw fat, percentage raw ash, percentage carbohydrade proportions have decreased to 36.69 ± 1.15%; 4.8 ± 0.28%; 13.76 ± 1.86%; 0.1 ± 0.01% in succession. After statistical comparison, it has been found out that this change is important ($p<0.05$). After the study of Ayas (2006) to find out the chemical composition of Rainbow Trout's (*Oncorhyncus mykiss*), Anchovy's (*Engraulis encrasicolus*) and Sardine's (*Sardina pilchardus*), the similar increases have been observed in the amounts of their raw protein, raw fat, raw ash and carbohydrade. The same researcher has linked the observed increases to dry material amount increase due to the water loss of smoked fillet. Furthermore he has found out that the decrease in amount of water in smoked samples has been a cause of the water lose in cooking process during smoking and the salt lost in salting process; and even if it is just a little, it has been the cause of mechanical process. Another researcher has stated that the pre smoking salting process applied to the trout and the heating process during the smoking process have considerably caused the decrease in moisture proportion and that due to this decrease there has been a proportional increase in the fat levels of the samples (Angiş et al., 2006a).

After the study, it has been found out that the heating process during salting, cooking and smoking has caused similar changes in some characteristics such as moisture and fat levels. As a matter of fact Ünlüsayin et al. (2001a) has stated that similar changes have occured in moisture, protein, ash, carbohydrade and fat amounts in his study to find out the changes in chemical lipids of European eel, rainbow trout and pike perch. It has been reported by Ünlüsayin et al. (2001b) that such changes have occured in another study to find out the protein contents of some fish species (pike-perch, European eel fish, rainbow trout fish) after smoking process. Similar results have been reported in various studies by Kolsarici and Özkaya (1998), Bilgin et al. (2001, 2007, 2008), Salan et al. (2006), Yanar et al. (2006), Duman and Patir (2007), Yanar (2007), Korkut (2008) and Şengör et al. (2008). As a result, similarities have been observed in decrease in moisture amount; increase in raw protein, raw fat, raw ash and carbohydrade upon spiny eel fish have been reported by different researchers in different researches. Fresh and hot smoked spiny eel fish is inadequate to meet the known 0.9 mg daily human metabolism need for vitamin A with its present vitamin A amount (0.04 mg/100 g to 0.15 mg/100 g); although it has been seen that it is adequate in meeting the vitamin E need which is reported to be (0.39 mg/100 to 2.37 mg/100 g) daily (Varlik et al., 2004). On the other hand, it is quite poor in term of vitamin A when compared to reported edible fresh European eel fish 0.08 mg/100 g, and it is rich in terms of vitamin E (Varlik et al., 2004) which is reported as 0.98 mg/100 g. It has been found out that it is quite rich in terms of mineral components of Fe which is reported as 1.26 ± 0.22 mg/100 g to 2.71 ± 0.60 mg/100 g) when compared various fish species (mackerel, morina, whiting, ringa, eel, trout) whose Fe amount have been reported to range between 0.44 to 1.1 mg/100 g. It can be said that it is an important Fe source when we think of the Fe's importance for human body (it carries oxygen to the cells as it is in the structure of hemoglobin) (Varlik et al., 2004).

When we regard its necessity that men should take 10 to 15 mg and women 7 to 11 mg daily, it has been concluded that the fresh smoked spiny eel fish is very good in terms of Zn (4.60 ± 0.94 mg/100 g to 2.44 ± 0.38 mg/100 g) (Zn makes up the main components of almost 50 enzymes, strenghtens the immune system, has an important role in configuration of cord tissue and activates different hormones). On the other hand, the fresh smoked spiny eel fish's Cu quantity which has a role in the components of various enzymes and these enzymes' transfer reactions and which is important for human nutrition have been found as 0.98 ± 0.01 mg/100 g and 0.12 ± 0.01 mg/100 g in succession. When it is thought that men and women have to take between 1.5 and 3 mg Cu on average (Varlik et al., 2004), the fresh and smoked spiny eel seems to be quite good. Studies upon fatty acids have shown that compositions of fatty acids of various fish species are different from each other; but fish fats include about 20% saturated and 80% unsaturated and over saturated fatty acids (Ünlüsayin et al., 2001a; Varlik et al., 2004). It has been found that saturated fatty acids, especially C16:0 (palmitic acid) and C14:0 (myristic acid) can change in fish as 13 to 19%, 4 to 8% in succession and that they play a secondary role (Varlik et al., 2004). As a result of the research, the discoveries about the fresh and spiny eel fish are close to these quantity (18.98% for C16:0; 3.34% for C14:0). After smoking process an increase has been observed in saturated fatty acids (SFA) (35.24%); and a decrease has been observed in mono and poly-unsaturated fatty acids (MUFA/PUFA) (43.93%). This shows that some unsaturated fatty acids have saturated and some of them have been demolished. As a matter of fact in another study by Ünlüsayin et al. (2001a), the fatty acids

compositions of fresh eel fish have been observed before smoking as 16.09% saturated; 83.91% unsaturated; and after the smoking process an increase has been observed in saturated fatty acids (24.65%); and a decrease has been observed in unsaturated fatty acids (75.35%). The discoveries found in the study have been to be in accordance with the reasearcher's study.

Kaya et al. (2008), in another study of his, upon Sturgeon (*H. huso* L.1758) has found the amounts of omega-3 fatty acids which are important in human nourishment, C20:5n–3 (EPA) and C22:6n–3 (DHA) in fresh fish as 4.65 and 12.41% in succession; but Kaya et al. (2008) has reported that these amounts have decreased to 0.49 and 0.51% after smoking process. Similarly, it has been reported that decreases have been observed in poly unsaturated fatty acids (PUFA) and it has decreased from 21.02 to 4.93%. Similar discoveries have been made in our study, too; the poly unsaturated fatty acids (PUFA) amount has decreased from 21.22 to 13.56% after smoking process. Decrease have been observed in EPA and DHA, which has an important role in decreasing the risk of heart attack and other illnesses (Kaya et al., 2004) after smoking process; EPA and DHA amounts have been observed as decreasing from 1.76 to 0.73%; from 9.36 to 4.69% in fresh and smoked spiny eel fish ($p<0.05$) in succession. It is thought that these decreases are due to the influence of heat treatment on some unsaturated fatty acids. As a result of the study, it has been concluded that the spiny eel is an important species in meeting the needs of elements Zn and Cu of the individuals as well as being a good Fe source and a good protein source. In addition to these, it has been found that it is poor in vitamin A but rich in vitamin E. It has also been found out that it has little fat proportion and energy; besides, in the study, it has been seen that thermal process applied during cooking and smoking has an effect of decreasing the quantity of essential fatty acid such as EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) particularly.

Also, when it is thought that the fat components of the material used in smoking being a main criteria in smoking technology, it has been concluded that the hot smoking process is not a convenient process for the spiny eel which includes little fat and it will be better to use alternative processing methods to evaluate.

ACKNOWLDGEMENT

This research has been funded by Research Projects Unit of University of Adiyaman (ADYÜBAP) (project number: KMYO BAP–2008/3).

REFERENCES

Aminullah BAKM, Ratnayake WMN, Ackman RG (1993). Nutritional composition of raw and smoked Atlantic mackerel (*Scomber scombrus*): oil- and water-soluble vitamins. J. Food Compos. Anal., 6: 172-184.

Angiş S, Oğuzhan P, Atamanalp M (2006a). The effect of the cold-bloating of rainbow trout (*Oncorhynchus mykiss*) on some chemical characteristics. First Fisheriessciences and Reservoir Management Symposium 7–9 February 2006, Antalya.

Angiş S, Oğuzhan P, Atamanalp M (2006b). Comparing the sensorial quality criterias in rainbow trout (*Oncorhynchus mykiss*) cold-bloated and cooked in the brazier. Aegean University Water Products Magazine, 23(1/3): 337-338.

Association of official analytical chemists (AOAC) (1995). Method 920.39, 925.10, 942.05, and 990.03. Association of Official Analytical Chemists Official Methods of Analysis 16th ed. USA: Washington.

Association of Official Analytical Chemists (AOAC) (2000). Methods 992.06 and 992.03. Official Methods of Analysis of AOAC International. 17th Ed. AOAC International, USA:Gaithersburg. MD.

Association of Official Analytical Chemists (AOAC) (2005). Method 999.10. Official Methods of Analysis of AOAC International, USA: Gaithersburg. MD.

Ayas D (2006). The differences in whole body chemical composition of the rainbow trout (*Oncorhynchus mykiss*), black sea pilchard (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) following hot smoking. E.U. J. Fish. Aquat. Sci., 23(1/3): 343-346.

Bilgin Ş, Ünlüsayin M, Gülyavuz H (2001). Evaluating of *Clarias gariepinus* according to different bloating technics and determination of its chemical component. Turk. J. Vet. Anim. Sci., 25: 309-312.

Bilgin Ş, Ertan, ÖO, İzci L (2007). Investigation on changes in the chemical composition of hot smoked *Salmo trutta macrostigma*, Dumeril 1858 stored different temperatures. J. Fish. Sci. com., 1(2): 68-80.

Bilgin Ş, Ünlüsayin M, Levent I, Günlü A (2008). The determination of the shelf life and some nutritional components of gilthead seabream (*Sparus aurata* L.,1758) after cold and hot smoking. Turk. J. Vet. Anim. Sci., 32(1): 49-56.

Cardinal M, Knockaert C, Torrissen O, Sigurgisladottir S, Mørkøre T, Thomassen M, Vallet JL (2001). Relation of smoking parameters to the yield, colour and sensory quality of smoked Atlantic salmon (*Salmo salar*). Food Res. Int., 34: 537-550.

Cardinal M, Gunnlaugsdottir H, Bjoernevik M, Ouisse A, Vallet JL, Leroi F (2004). Sensory characteristics of cold-smoked Atlantic salmon (*Salmo salar*) from European market and relationships with chemical, physical and microbiological measurements. Food Res. Int., 37: 181-193.

Çakli Ş (2007). Fishery Products Processing Technology (Main Subjects on Fishery Products Processing Technology). Ege University Press. Facul. Fish., 76-696.

Çakmak E (2008). Determination of the morphological and molecular characteristics of spiny eel (*Mastacembelus mastacembelus*). MSc thesis. University of Kahramanmaraş Sütçü İmam Institute for Graduate Stud. Sci. Eng. Depart. Aquacult., p.50

Dondero M, Cisternas F, Carvajal L, Simpson R (2004). Changes in quality of vacuum-packed cold-smoked salmon (*Salmo salar*) as a function of storage temperature. Food Chem., 87: 543- 550.

Duman M, Patir B (2007). Determination of some chemical and sensory characteristics of smoked mirror carp (*Cyprinus carpio* L.) fillets. Sci. Eng. J. Firat Univ., 19 (4): 463-472.

Eroğlu M (2004). Reproduction biology of Mastacembelus simack (Walbaum, 1792) living in Karakaya Dam Lake. MSc Thesis, Firat University, Graduate School Nat. Appl. Sci., 47s.

Goulas AE, Kontominas MG (2005). Effect of salting and smoking-method on the keeping quality of chub mackerel (*Scomber japonicus*): biochemical and sensory attributes. Food Chem., 93: 511-520.

Gümüş A, Şahinöz E, Doğu Z, Polat N (2010). Age and growth of the Mesopotamian spiny eel, *Mastacembelus mastacembelus* (Banks & Solender, 1794), from southeastern Anatolia. Turk. J. Zool., 34: 399-407.

Günlü A (2007). Determination of Shelf Life and changes of some nutrient components after smoking process of cultured sea bass (*Dicentrarchus labrax* L. 1758) Ph.D. thesis, T.C. Süleyman Demirel University, Instit. Sci., p. 123.

Indrasena WM, Hansen LT, Gill TA (2000). Effect of cold-smoking and drying on the textural properties of farmed Atlantic salmon (*Salmo salar*). J. Aquat. Food Prod. T., 9: 1,47-64.

International Union of Pure and Applied Chemistry (IUPAC) (1979). Standard Methods for Analysis of Oils, Fats and Derivates, 6th Ed. (Fifth Edition Method II.D.19) 96-102. Pergamon Pres, Oxford.

Kaya Y, Duyar H, Erdem ME (2004). The importance of the fish oil acids on human health. E.U. J. Fish. Aquat. Sci., 21 (3-4): 365-370.

Kaya Y, Turan H, Erkoyuncu İ, Sönmez G (2006). The storage in chilled conditions of hot smoked bonito (*Sarda sarda* Bloch, 1793). E.U. J. Fish. Aquat. Sci., 23 (1/3): 457-460.

Kaya Y, Turan H, Erdem ME (2008). Fatty acid and amino acid composition of raw and hot smoked sturgeon (*Huso huso* L. 1758). Int. J. Food Sci. Nutr., 59(7-8): 635-642.

Kolsarici N, Özkaya Ö (1998). Bloating technics on shelf life of rainbow trout and the effect of storing heat. Turk. J. Vet. Anim. Sci., 22: 273-284.

Kiliç HM (2002). The investigation of biological properties of Mastacembelus simack living in Sultansuyu Stream, Beyler Stream and Karakaya. Osmangazi University, Graduate School Nat. Appl. Sci. p. 30.

Korkut SO (2008). Some chemical and microbiological changes happened during the protection of smoked tench (*Tinca tinca* L.,1758) in different packets and fridge circumstances. MSc thesis, University of Afyon Kocatepe, Depart. Food Eng., p. 61.

Oğuzhan P, Angiş S, Haliloğlu HI, Atamanalp M (2006). Chemical composition changes in rainbow trout fillets after hot-bloating. E.U. J. Fish. Aquat. Sci., 23(1/3): 465-466.

Patir D, Duman M (2006). Determination of the physico-chemical and microbiological changes happened during the protection of bloated mirror carp (*Cyprinus carpio* L.) fillets. Sci. Eng. J. Firat Univ., 18(2): 189-195.

Pizara A, Abdoli A, Kouhgardi E, Yousefifard P (2005). Age structure and growth of the Mesopotamian spiny eel, *Mastacembelus mastacembelus* (Bank and Solender in Russell, 1794) (Mastacembelidae), in Southern. Iran. Zool. Mid. East., 35: 43-47.

Salan EO, Galvao JA, Oetterer M (2006). Use of smoking to add value to the salmoned trout. Braz. Arch. Biol. Technol., 49: 57-62.

Şahinöz E, Doğu Z, Aral F (2006). Development of embryos in *Mastacembelus mastacembelus* (Bank&Solender, 1794) (Mesopotamian Spiny Eel) (Mastacembelidae). Aquac. Res., 37(16): 1611-1616.

Şahinöz E, Aral F, Doğu Z (2007). Changes in Mesopotamian spiny eel, *Mastacembelus mastacembelus* (Bank & Solender in Russell, 1794) (Mastacembelidae) milt quality during a spawning period. Theriogenology, 1:67(4): 848-54.

Şengör GF, Gün H, Kalafatoğlu H (2008). Determination of the amino acid and chemical composition of canned smoked mussels (*Mytilus galloprovincialis*, L.) Turk. J. Vet. Anim. Sci., 32 (1): 1-5.

Ünlüsayin M, Aksoylar M Y, Gülyavuz H (2001a). Chemical changes of some freshwater fish's lipids after hot-smoking. Turk. J. Vet. Anim. Sci., 25: 341-348.

Ünlüsayin M, Kaleli S, Gülyavuz H (2001b). The determination of flesh productivity and protein components of some fish species after hot smoking. J. Sci. Food. Agric., 81: 661-664.

Watt BK, Merrill AL (1975). Composition of Foods: Raw, Processed and Prepared (Agriculture Handbook No. 8). United States Department of Agriculture Washington D.C, p.190.

Varlik C, Erkan N, Özden Ö, Mol S, Baygar T (2004). Fishery Products Proccessing Technology. Istanbul University. Press Number: 4465. Faculty of Fisheries. Number, 7491s.

Vasiliadou S, Ambrosiadis I, Vareltzis K, Fletouris D, Gavriilidou I (2005). Effect of smoking on quality parameters of farmed gilthead sea bream (*Sparus aurata* L.) and sensory attributes of the smoked product. Eur. Food Res. Technol., 221: 232-236.

Yanar Y, Çelik M, Akamca E (2006). Effects of brine concentration on shelf life hot smoked tilapia (*Oreochromis niloticus*) stored at 4˚C. Food Chemis., 97: 244-247.

Yanar Y (2007). Quality changes of hot smoked catfish (*Clarias gariepinus*) during refrigerated storage. J. Muscle Foods, 18: 391-400.