8(1): 17-26 (2014) DOI: 10.3153/jfscom.2014003

Journal of FisheriesSciences.com

E-ISSN 1307-234X

ORIGINAL ARTICLE/ORİJİNAL ÇALIŞMA

FULL PAPER TAM MAKALE

CHEMICAL COMPOSITION, CHOLESTEROL, TRACE METALS AND AMINO ACID COMPOSITION OF DIFFERENT CANNED FISH PRODUCTS PRODUCED AND SOLD IN TURKEY

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Received: 20.03.2013 / Accepted: 01.10.2013 / Published online: 28.12.2013

Abstract: Commercial Turkish canned fish products were analysed for chemical composition and food quality attributes inclusive potentially toxic heavy metals of the fish content (anchovy, sardine, mackerel, bonito, and trout). The average fat content ranged from 6.7% (trout) to 24.3% (mackerel). Cholesterol was low (41-69 mg/100g). No phosphate based additives have been added during production. The samples contained high amounts of taurine (20-67 mg/100 g) and histidine (146-424 mg/100g, except trout). The cadmium and lead concentrations were below the Turkish Food Codex and EU limits (4.0-19.8 µg/kg and 16.7-60.6 µg/kg, respectively). Zinc ranged from low contents in mackerel, bonito and trout (5.8-6.9 mg/kg) to higher contents in anchovy and sardine (27.3 and 17.6 mg/kg). Copper concentrations were found to be low around 0.5 mg/kg.

Keywords: Canned fish, Chemical composition, Trace metals, Free amino acids, Cholesterol, Taurine

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Journal abbreviation: **J FisheriesSciences.com**

Öz:

Türkiye'de Üretilen ve Satılan Farklı Konserve Balık Ürünlerinin Kimyasal Kompozisyon, Kolestrol, İz Metal ve Amino Asit Kompozisyon Değerleri

Ticari Türk konserve balık ürünleri (hamsi, sardalya, uskumru, palamut, alabalık) potansiyel toksik ağır metalleri içeren gıda kalite özellikleri ve kimyasal kompozisyonu için analiz edilmiştir. Ortalama yağ içeriği alabalıkta % 6.7'den uskumruda %24.3'e kadar değişim göstermiştir. 41-69 mg/100 g olarak bulunan kolestrol değerleri düşük bulunmuştur. Üretim boyunca fosfat bazlı katkılar eklenmemiştir. Numuneler yüksek miktarda taurin (20-67 mg/100 g) ve histidin (146-424 mg/100 g, alabalık hariç) içermektedirler. Kadmiyum ve kurşun konsantrasyonları Türk Gıda Kodeksi ve Avrupa limit değerlerinin (sırayla 4.0-19.8 µg/kg vve 16.7-60.6 µg/kg) altında bulunmuştur. Çinko, uskumru, palamut ve alabalıkta 5.8-6.9 mg/kg olarak düşük, hamsi ve sardalyada 27.3 and 17.6 mg/kg olarak daha yüksek değerlerde tespit edilmiştir. 0.5 mg/kg civarında tespit edilen bakır konsantrasyonları düşük olarak bulunmuştur.

Anahtar Kelimeler: Konserve balık, Kimyasal kompozisyon, İz metaller, Serbest amino asitler, Kolesterol, Taurine

Introduction

In a recent paper (Aydin 2011) about fish and fishery products consumption in Turkey it was demonstrated that 32% of Turkish households consumed such products when taking the average of the last 12 years while the remaining 68% did not consume fish at all.

Another study (Erdoğan et al. 2011) demonstrated that canned seafood was most preferred (37.6%) followed by frozen seafood products (26.8%).

This underlines the importance to have a good and comprehensive knowledge about the nutritional properties and present risks in canned products processed in Turkey from Turkish raw materials. In canned products a number of nutritionally important components as amino acids, taurine, selenium, and lipids are present but also the occurrence of heavy metals as cadmium and lead are reported. The concentrations of all toxic elements and essential elements in selected products like canned anchovy or tuna fillets were found to be high and often exceeded legal limits set by health authorities (Celik et al. 2007). Therefore the authors concluded that these products must be monitored more often. Data about other components such as cholesterol content, phosphorous, alkali elements and heavy metals as zinc and copper are almost lacking.

Also in the raw fish material from Turkish waters which can be used for canning elevated concentrations of heavy metals have been reported (Celik et al. 2004; Dalman et al. 2006; Ersoy et al. 2010; Mendil et al. 2010; Mol et al. 2012; Tuzen 2009; Uluozlu et al. 2007; Yildirim et al. 2009; Yilmaz et al. 2010).

In the case of canned fish production a storage process (chilling or freezing) is needed for storing the raw material prior to canning. A heating step (cooking, smoking, and frying) is normally applied for reducing water content and inactivating endogenous enzyme activity. A rigorous thermal treatment (sterilization) is undertaken to inactivate micro-organisms and to guarantee a prolonged shelf life. Labile and essential nutrients (proteins, vitamins, lipids, minerals) present in the raw fish are exposed to different processing conditions that can reduce the nutritional and sensory values of the final product (Aubourg 2001).

Amino acids are not only components of all peptides and proteins but also precursor compounds relevant to food flavour, taste and colouring (Belitz et al. 2009). The content of free amino acids in food and their losses due to industrial processing are also interesting because of nutritional aspects. Very remarkable is the content of taurine in fish. Taurine is a conditional essential free amino acid with several health-beneficial effects (Undeland 2009).

In this investigation both, nutritional positive components as well as potentially harmful elements as heavy metals have been analysed to give a good overview about the nutritional value of the canned fish products from Turkey.

Materials and Methods

Samples and Sample Preparation

Commercial brands of canned fish products were purchased in retail stores in Izmir, Turkey. Products chosen are typically consumed in Turkey. The samples analysed consisted of whole anchovy in oil (Dardanel Hamsi sosyete), headed sardine in oil (Dardanel sardalya), mackerel fillet in own juice (Migros Uskumru), bonito fillet in own juice (Migros Palamut), and trout fillet in tomato sauce (Migros Alabalik), 5 cans each.

The chemical analyses were performed in Hamburg, Germany. Convenient aliquots or pooled samples (depending on the amount of material) of the dripped fish part were homogenized in a knife mill and taken for analyses.

Proximate Analyses

Moisture was determined gravimetrically in an aliquot of the homogenate after drying for 12h in an oven at 105 °C until weight was constant. Percent raw protein was calculated by multiplying nitrogen (%) by 6.25 (nitrogen was measured by Dumas using a LECO TruSpecN (LECO instruments GmbH, Mönchengladbach, Germany)) (AOAC 2005). The lipid content was analyzed by a modified method of Smedes (1999) (Karl et al. 2012).

Ash content was determined according to Antonacopoulus (1973). The amount of salt was obtained by titration with 0.1 N $AgNO_3$ solution after protein precipitation with Carrez I and Carrez II (Karl et al. 2002).

Cholesterol Content

Cholesterol was analyzed according to the method and quantification based on the experimental procedure of Naemmi et al (1995) as modified by Oehlenschläger (2006).

Total Phosphorus Content

The total phosphorus content was determined photometrically in the nitric acid extract of the ash according to a modified official German method of the foodstuffs and animal feed code to measure phosphorus in meat (§ 64 LFGB 2008).

Free Amino Acid Composition

For sample deproteinization 10 g fish sample were homogenized with 90 mL 6 % perchloric acid (w/w) and subsequently filtrated. HPLC determination of the free amino acids (17, including taurine) was performed in the diluted extracts (1:10 up to 1:200). After precolumn derivatization with o-phthaldialdehyde (OPA) according to a modified method of Antoine and co-workers (1999), the amino acids were separated on a reversed-phase column by a gradient and then quantified by fluorescence detection using the internal standard method with 2-aminobutyric acid.

Mineral Element Analysis

The homogenised fish samples (1.6 – 2.0 mg wet weight) were digested in a mixture of 4 mL 65% nitric acid suprapur and 1 mL 30% hydrogen peroxide in closed tetrafluormethaxil quarz vessels of a temperature-time programmed Milestone ultraCLAVE III (Milestone SRL, Sorisole, Italy) digestion system.

Na, K, Ca and Mg were measured by flame AAS (contrAA® 700 high-resolution continuum source atomic absorption spectrometer with air-acetylene flame equipped with an autosampler, Analytik Jena, Jena, Germany).

Selenium Measurements

The samples were prepared as described above. Selenium was analyzed by the continuous flow hydride system of the contrAA® 700. For the reduction of Se (VI) to Se (IV) prior to the hydride generation 6 M HCl was added to an aliquot of the sample solution (1:1 v/v) and heated in a water bath for 30 min at 90 °C.

Quality Assurance of AAS Determination

The commercial reference material IAEA-407 of the International Atomic Energy Agency was used to validate the analytical methods and as quality control. The mean values obtained for analytical recovery were 101% (Na), 100% (K), 89% (Ca), 82% (Mg) and 83% (Se) (Table 1).

Heavy Metals

All samples were lyophilised in a Finn-Aqua Lyovac GT 2 freeze dryer (GEA Process Engineering Inc., Columbia, U.S.), milled in a ball mill made from agate and finally decomposed in an oxygen plasma ashing chamber. Differential pulse anodic stripping voltammetry (746 VA Trace Analyser, Metrohm, Switzerland) was used for the determination under the same experimental conditions, as described elsewhere in detail (Celik et al 2007). For analytical quality control the recommendations given in the guidelines of NMKL (2011) are followed whenever possible. The accuracy of the concentrations deter-

mined in this study was verified by measurements of certified reference materials. Results given in Table 1 show that all elements were determined with good accuracy.

Statistical Evaluation

One-way ANOVA (Tukey-Test) was applied for statistical analysis (SigmaStat version 3.5, Systat software Inc., San Jose, U.S.).

Results and Discussion

Proximate Composition and Cholesterol Content

The basic nutritional ingredients show that the canned fish products contained considerable amounts of raw protein. The highest average raw protein content was measured in bonito (23.6%) and the lowest in trout fillets (17.0%) (Table 2). The average fat content ranged between 6.7% (trout) and 24.3% (mackerel). Fish lipids are a very good source of essential unsaturated fatty acids. The consumption of such products can help to cover the daily amounts of valuable long chain unsaturated omega-3 fatty acids recommended for the prevention of heart diseases.

Table 1. Quality Assurance (QA) for elemental analyses based on certified reference materials. Concentrations based on a dry weight basis

	No. of analyses	Units	Results	Certified reference material	
				IAEA 407	CRM No. 422
Sodium	6	g/kg	13.29 ± 0.55 (101.5%)	13.10 ± 0.70	
Potassium	6	g/kg	13.29 ± 0,56 (101.5%)	13.10 ± 0.90	
Calcium	6	g/kg	24.22 ± 2.61 (89.4%)	27.00 ± 1.30	
Magnesium	6	g/kg	2.34 ± 0.08 (82.1%)	2.72 ± 0.14	
Selenium	10	mg/kg	2.39 ± 0.14 (84.5%)	2.83 ± 0.38	
Cadmium	5 5	µg/kg µg/kg	138.4 ± 29.4 (73.2%) 17.5 ± 0.75 (102.8%)	189.0 ± 4.0	 17.0 ± 2.0
Lead	5 5	µg/kg µg/kg	149.9 ± 25.2 (124.1%) 81.4 ± 9.41 (95.8%)	120.0 ± 20.0	 85.0 ± 15.0
Copper	5 5	µg/kg µg/kg	2.32 ± 0.56 (70.7%) 1.08 ± 0.09 (103.0%)	3.28 ± 0.08	 1.05 ± 0.07
Zinc	5 5	µg/kg µg/kg	66.3 ±14.2 (98.8%) 17.3 ± 1.0 (88.4%)	67.1 ± 0.8	 19.6 ± 0.5

Table 2. Proximate composition and cholesterol content of canned fish products from Turkey (arithmetic mean ± standard deviation, range: min – max, on a wet weight basis)

Fish Component	N	Anchovy, whole, in oil	Sardine, headed, in oil	Mackerel, fillet in own juice	Bonito, fillet in own juice	Trout, fillet in tomato sauce
Cholesterol [mg/100 g]	5	68.8 ± 6.0 60 – 76	64.6 ± 6.4 58 – 74	41.0 ± 8.9 26 - 48	51.6 ± 4.4 47 - 58	48.4 ± 4.4 41 - 52
Moisture [g/100 g]	5	61.6 ± 1.8 59.3 – 64.0	60.6 ± 1.9 57.9 – 62.5	55.3 ± 2.6 51.7 – 58.3	59.9 ± 1,7 58.3 – 62.3	70.7 ± 0.8 69.6 – 71.8
Ash [g/100 g]	5*	2.7	3.2	1.4	1.3	2.1
Raw protein (N x 6.25) [g/100 g]	5	18.1± 0.3 17.8–18.5	18.6 ± 1.5 16.2 – 20.1	18.1 ± 1.8 16.6 – 21.1	23.6 ± 0.8 22.9 – 24.7	17.0 ± 0.4 16.4–17.4
Total lipids [g/100 g]	5*	12.5	11.7	24.3	15.1	6.7
NaCl [g/100 g]	5*	1.3	1.2	0.7	0.5	1.3
Phosphate (P_2O_5) [g/100 g]	5*	0.8	1.0	0.4	0.5	0.4
Sodium [mg/ kg]	5	4379 ± 371 3973 – 4729	4653 ± 507 4272 – 5460	2452 ± 304 2040 – 2811	1911 ± 214 1707 – 2246	4919 ± 572 4226 – 5754
Potassium [mg/ kg]	5	2307 ± 160 2060 – 2450	2282 ± 250 1931– 2535	2604 ± 269 2244 – 2941	2853± 92 2751– 2945	3443 ± 80 3348 – 3566
Magnesium [mg/ kg]	5	286 ± 12 269 – 303	354 ± 9 341– 363	228 ± 27 192 – 264	279 ± 10 269 – 291	217 ± 3 212 – 221
Calcium [mg/ kg]	5	2349 ± 342 1988 – 2734	3601 ± 313 3194 – 4020	nn	nn	nn

*) pooled samples nn< limit of detection 70-100 mg Ca/kg (based on threefold standard deviation of the blanks and an average sample weight)

Fish products are usually not a considerable source for cholesterol via food intake. In raw fish from the Northeast Atlantic an average of approx. 40 mg/100 g was determined. Fish species from temperate areas can have slightly higher values (Oehlenschläger 2006). Levels between 41 and 69 mg cholesterol/100 g in the canned fish species were in the low range and confirm that the cholesterol content does not correlate with the respective lipid values. It could also be confirmed that there is no increase of cholesterol in the fish caused by other ingredients.

Mineral Element Analysis

Marine food serves as a moderate to good source of minerals. Fish flesh generally contains high amounts of potassium (around 0.35 g/100g and low amounts of sodium (around 0.04 g/100g) (Holland et al 1993; Oehlenschläger 1997; Oehlenschläger et al 2009). In the samples investigated the natural amounts of sodium have been increased by the addition of salt to contents between 0.5 and 1.3 gNaCl/100g while potassium remained at its natural content (0.228 -0.344 g/100g, Table 2).

The level of magnesium in the raw and boneless muscle is higher (average 0.025 g/100g) than the calcium content which is confirmed by the results of the canned fillets in Table 2. Only fish eaten with bones like anchovy and sardines is an excellent source for calcium (Holland et al. 1993), in boneless canned fish the calcium content was below the limit of detection.

The phosphorous content is somewhat higher in canned fish, where the bones are in and lower in boneless fillets. From the data in Table 2 it is evident that all phosphorous present is natural (0.4–1.0 g P_2O_5/100g) and no phosphate based additives have been added during production.

Particularly worth mentioning is selenium as an essential micronutrient which plays a vital role in human health. Fish is an important and highly bio-available source of dietary selenium. The content of this element can vary considerably between specimens, but is on average quite constant between species. Marine fish from the Northeast Atlantic waters contains between 0.3 and 0.6 mg selenium/kg, values for freshwater fish can be somewhat lower (Oehlenschläger 2006). The re-

sults of this study (Table 3) confirm these findings. The recommended daily allowances of selenium of 0.03-0.07 mg of the German Nutrition Society (2008) are already covered by the consumption of about 100 g of the analysed fish species.

The results for the element traces are presented in Table 3. All cadmium concentrations found were well below the legal Turkish Food Codex and the strictest EU limits (100 µg/kg (Anonymous 2008) and 50 µg/kg wet weight, respectively). The highest amount 20 µg/kg was present in anchovy; the other 4 samples contained only 4-7 µg/kg. The values for anchovy were low compared with literature data that reported for fresh anchovy 650 µg/kg (Uluozlu et al. 2007) and 270 µg/kg (Tuzen 2009). For canned anchovy Tuzen and Soylak (2007) and Celik et al. (2007) published 120 µg/kg and 92 µg/kg, respectively. In contrast, Mol (2011a) found lower cadmium contents in canned anchovy ranging between 1 and 19 µg/kg which are in good agreement with the figures reported in this paper. For canned sardine and tuna 190 µg/kg and 80 µg/kg, respectively, were analyzed (Tuzen et al. 2007). Similar and comparable low cadmium concentrations of 10-20 µg/kg in canned tuna were published in 2011 by Mol (2011b). However, in a recent study about trace elements in vacuum packed smoked Turkish rainbow trout, a cadmium content of 10 µg/kg was found (Sireli et al. 2006). Galitsopoulou (2012) explained a certain increase in cadmium content of anchovies and sardines after canning compared to the raw material used by the water reduction process prior to canning.

The Turkish Food Codex permits 300 µg/kg as maximum lead level in fish (Anonymous 2002). The lead contents were also all below this limit, ranging from 17 µg/kg in bonito fillet to 61 µg/kg in sardine. 90 µg Pb/kg have been reported by Tuzen (2009) in canned sardine which is close to the amount found in this investigation, but the author found a much higher lead content in canned anchovy (400 µg/kg). Mol (2011a) reported in canned anchovies a lead concentration of 188 µg/kg which exceeds the results of this investigation by a factor of 5. In canned tuna a lead content ranging between 90 and 450 µg/kg was reported by Mol (2011b). The significantly higher lead concentration in canned products containing bones can be explained by the fact that lead can be accumulated in bone tissue (Oehlenschläger 2002).

All samples contained zinc ranging from a low content in mackerel (6.9 mg/kg), bonito (5.8 mg/kg) and trout (6.4 mg/kg) to a higher content in anchovy and sardine (27.3 mg/kg and 17.6 mg/kg). This is in good agreement with other findings where 34.0 mg/kg have been found in canned anchovy and 7.5 mg/kg in canned sardine (Tuzen 2009). In canned tuna a zinc concentration between 8.2 and 12.4 mg/kg was given by Mol (2011b).

Copper concentrations were found to be low around 0.5 mg/kg. These values were lower than those reported by Tuzen (2009) (1.8 mg/kg for anchovy and 2 mg/kg for sardine), but in good agreement with the copper content reported for canned tuna (0.45-0.58 mg/kg) by Mol (2011b).

Free Amino Acids

The total content of free amino acids varied clearly among species and between single cans of the same product (Table 4). In cans containing marine fish species individual amino acids such as asparagine, aspartic acid, phenylalanine and isoleucine were found only in minimal quantities. In trout products the levels of asparagine, aspartic acid and particularly glutamic acid were much higher.

In all tested fish cans the high levels of taurine became obvious. Taurine is an amino sulfonic acid that is never incorporated into proteins, but is present in free form only in animal tissues. Humans are limited capable of biosynthesising taurine, but it is of importance for many physiological processes. For example taurine is beneficial for cardiovascular health, reduces blood cholesterol values, and has antioxidant properties (Undeland 2009). Taurine is a heat stable, water soluble compound of low molecular weight. It is a known fact that during processing of fish the concentration of taurine decreased mainly as a result of leaching (Dragnes et al. 2009; Larsen et al. 2010). Because the raw fish was not analysed, a calculation of the loss of taurine and other free amino acids during processing was not possible.

The taurine content in the fish products (except for trout) was only exceeded by the histidine content. Especially marine fish contained high amounts exceeding the limit of the analytical determination procedure. The actual levels are therefore higher. Some free amino acids like histidine or lysine can result in the rapid formation of biogenic amines during microbial spoilage of fish.

Table 3. Trace elements in the edible part of canned fish products from Turkey (arithmetic mean ± standard deviation, range: min-max on a wet weight basis), n = 5 cans, respectively

Component	Anchovy, whole, in oil	Sardine, headed, in oil	Mackerel, fillet in own juice	Bonito, fillet in own juice	Trout, fillet in tomato sauce
Selenium	0.43 ± 0.06^{a}	0.71 ± 0.21^{bc}	0.40 ± 0.07^{a}	0.63 ± 0.04^{c}	0.20 ± 0.01^{d}
[mg/kg]	0.37 – 0.53	0.51 – 1.05	0.34 – 0.52	0.56 – 0.66	0.18 – 0.21
Zinc	27.3 ± 1.8^{a}	17.6 ± 1.7^{b}	6.9 ± 0.5^{c}	5.8 ± 0.3^{c}	6.4 ± 0.5^{c}
[mg/kg]	25.3 – 30.1	15.4 – 20.1	6.1 –7.4	5.4 – 6.1	5.5 – 6.9
Copper	0.8 ± 0.1^{a}	0.7 ± 0.1^{a}	0.9 ± 0.1^{a}	0.5 ± 0.1^{b}	0.5 ± 0.1^{b}
[mg/kg]	0.6 – 0.9	0.6 – 0.9	0.7 – 1.1	0.5 – 0.6	0.4 – 0.6
Cadmium	19.8 ± 4.2^{a}	6.8 ± 2.8^{b}	5.9 ± 1.0^{b}	4.6 ± 0.7^{b}	4.0 ± 0.5^{b}
[µg/kg]	13.9 – 23.8	3.9 – 10.9	4.7 – 7.0	3.5 – 5.2	3.3 – 4.5
Lead	35.8 ± 3.8^{a}	60.6 ± 14.1^{b}	17.5 ± 1.8^{c}	16.7 ± 3.8^{c}	18.3 ± 3.4^{c}
[µg/kg]	32.9 – 41.9	48.4 – 84.5	15.6 – 19.9	12.7 – 22.4	12.8 – 21.9

Different letters in a horizontal block indicate a statistically significant difference in the mean values ($p < 0.05$)

Table 4. Free amino acid content of canned fish products from Turkey (arithmetic mean ± standard deviation on a wet weight basis), n = 5 cans, respectively

Amino acid [mg/g fish]	Anchovy, whole, in oil	Sardine, headed, in oil	Mackerel, fillet in own juice	Bonito, fillet in own juice	Trout, fillet in tomato sauce
Aspartic acid	nn	0.02 ± 0.03	nn	nn	0.16 ± 0.02
Glutamic acid	0.16 ± 0.07	0.05 ± 0.02	0.06 ± 0.02	0.05 ± 0.03	0.35 ± 0.04
Asparagine	nn	nn	nn	nn	0.13 ± 0.02
Serine	0.03 ± 0.02	0.10 ± 0.14	0.02 ± 0.03	0.02 ± 0.02	0.06 ± 0.01
Histidine	2.10 ± 1.07^{ab}	1.46 ± 0.55^{ab}	1.53 ± 0.41^{ab}	4.24 ± 1.11^{a}	0.19 ± 0.05^{b}
Arginine	0.09 ± 0.02	0.14 ± 0.14	0.03 ± .005	nn	0.05 ± 0.01
Glycine	0.15 ± 0.07	0.11 ± 0.06	0.10 ± 0.02	0.21 ± 0.08	0.17 ± 0.05
Threonine	0.15 ± 0.07	0.09 ± 0.04	0.08 ± 0.02	0.21 ± 0.10	0.06 ± 0.01
Taurine	0.67 ± 0.31^{a}	0.46 ± 0.12^{ab}	0.50 ± 0.11^{a}	0.26 ± 0.08^{ab}	0.20 ± 0.04^{b}
Tyrosine	0.06 ± 0.03	nn	0.01	nn	0.01 ± 0.01
Alanine	0.36 ± 0.17	0.12 ± 0.03	0.09 ± 0.02	0.05 ± 0.03	0.28 ± 0.03
Methionine	0.09 ± 0.04	0.02 ± 0.03	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01
Valine	0.11 ± 0.05	0.06 ± 0.04	0.02 ± 0.01	0.01 ± 0.02	0.02 ± 0.02
Phenylalanine	0.09 ± 0.04	nn	nn	nn	0.02 ± 0.02
Isoleucine	0.09 ± 0.04	nn	nn	nn	0.01 ± 0.01
Leucine	0.17 ± 0.08	0.04 ± 0.03	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01
Lysine	0.18 ± 0.06	0.10 ± 0.03	0.15 ± 0.03	0.09 ± 0.06	0.09 ± 0.01
Total	4.49 ± 2.12^{ab}	2.80 ± 0.85^{ab}	2.61 ± 0.57^{ab}	5.17 ± 1.49^{a}	1.83 ± 0.27^{b}

nn: < limit of detection 0.01 mg/g

Different letters in a horizontal block indicate a statistically significant difference in the mean values ($p < 0.05$)

Conclusions

The canned fish products investigated can be described as products rich in protein and fat with low cholesterol content. They are a good source of magnesium, zinc and selenium and those containing bones also of phosphorous. No phosphates were added as additives. The samples contained high amounts of taurine and histidine. The contents of the heavy metals lead and cadmium were below legal Turkish limits. These canned products produced and marketed in Turkey are from a nutritional point of view recommended to be consumed.

Acknowledgement

The skilful technical assistance of S. Blechner (elements), I. Delgado and H.-J. Knaack (proximate composition), T. Schmidt (amino acids), and I. Wilhelms (cholesterol) is gratefully acknowledged.

References

Anonymous, (2002). Regulation of setting maximum levels for certain contaminants in foodstuffs. Official Gazette, Issn: 24908.

Anonymous, (2008). Regulation of setting maximum levels for certain contaminants in foodstuffs. Official Gazette, Issn: 26879.

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

doi: 10.1021/jf990032+

Antonacopoulos, N., (1973). Lebensmittelchemisch-rechtliche Untersuchung und Beurteilung von Fischen und Fischerzeugnissen. In: W. Ludorff & V. Meyer (Eds.): *Fische und Fischerzeugnisse* (p. 219). Berlin/ Hamburg, Germany: Paul Parey Verlag.

AOAC, (2005). Method #968.06. *Official methods of analysis of AOAC International, 18th Edition.* AOAC International, Gaithersburg, U.S.

Aubourg, S.P., (2001). Review: Loss of quality during the manufacture of canned fish products, *Food Science and Technology International*, **7**: 199-215.

doi: 10.1106/4H8U-9GAD-VMG0-3GLR

Aydin, H., Dilek, M.K., Aydin, K. (2011). Trends in fish and fishery products consumption in Turkey, *Turkish Journal of Fisheries and Aquatic Sciences*, **11**: 499-506.

doi: 10.4194/trjfas.2011.0318

Belitz, H.D., Grosch W., Schieberle P., (2009). Amino acids, peptides, proteins. In: *Food Chemistry* (4th revised and extended Edition) (pp. 8-89). Berlin/Heidelberg, Germany: Springer Verlag.

Celik, U., Oehlenschläger, J., (2007). High contents of cadmium, lead, zinc and copper in popular fishery products sold in Turkish supermarkets, *Food Control*, **18**: 258-261.

doi: 10.1016/j.foodcont.2005.10.004

Celik, U., Cakli, S., Oehlenschläger, J., (2004). Determination of the lead and cadmium burden in some north eastern Atlantic and Mediterranean fish species by DPSAV, *European Food Research and Technology*, **218**: 298–305.

doi: 10.1007/s00217-003-0840-y

Dalman Ö., Demirak A., Balci A., (2006). Determination of heavy metals (Cd, Pb) and trace elements (Cu, Zn) in sediments and fish of the Southeastern Aegean Sea (Turkey) by atomic absorption spectrometry, *Food Chemistry*, **95**: 157-162.

doi: 10.1016/j.foodchem.2005.02.009

Dragnes, B.T., Larsen, R., Ernstsen, M.H., Mæhre, H., Elvevoll, E.O., (2009). Impact of processing on the taurine content in processed seafood and their corresponding unprocessed raw materials, *International Journal of Food Sciences and Nutrition*, **60**: 143-152.

doi: 10.1080/09637480701621654

Erdoğan, B.E., Mol, S., Coşansu, S., (2011). Factors influencing the consumption of seafood in Istanbul, Turkey, *Turkish Journal of Fisheries and Aquatic Sciences*, **11**: 631-639.

doi: 10.4194/1303-2712-v11_4_18

Ersoy B., Celik U., (2010). The essential and toxic elements in tissues of six commercial demersal fish from Eastern Mediterranean Sea, *Food and Chemical Toxicology*, **48**: 1377-1383.

doi: 10.1016/j.fct.2010.03.004

Galitsopoulou, A., Georgantelis D., Kontominas M., (2012). The influence of industrial-scale canning on cadmium and lead levels in sardines and anchovies from commercial fishing centres of the Mediterranean Sea, *Food Additives & Contaminants: Part B, 5*: 75-81.

doi: 10.1080/19393210.2012.658582

German Nutrition Society (Deutsche Gesellschaft für Ernährung) (2008). The reference values for nutrient intake (in German). Retrieved March 15, 2013 from: **http://www.dge.de**

Holland, B., Brown, J., Buss, D.H., (1993). In: Fish and Fish Products. 3. Supplement to the 5th Edition of McCance and Widdowson´s "The Composition of Foods". The Royal Society of Chemistry. London, UK.: Clays LTD.

Karl, H., Äkesson, G., Etienne, M., Huidobro A., Luten, J., Mendes, R., Tejada, M., Oehlenschläger, J., (2002). WEFTA interlaboratory comparison on salt determination in fishery products, *Journal of Aquatic Food Product Technology*, **11**: 215-228.

doi: 10.1300/J030v11n03_17

Karl, H., Bekaert, K., Berge, J-P., Cadun, A., Duflos, G., Oehlenschläger, J., Poli, B., Tejada, M., Testi, S., Timm-Heinrich, M., (2012). WEFTA interlaboratory comparison on total lipid determination in fishery products using the Smedes method, *Journal of AOAC International*, **95**: 1-5.

doi: 10.5740/jaoacint.11-041

Larsen, R., Mierke-Klemeyer, S., Mæhre, H., Elvevoll, E.O., Bandarra, N.M., Cordeiro, A.R., Nunes, M.L., Schram, E., Luten, J., Oehlenschläger, J., (2010). Retention of health beneficial components during hot- and cold-smoking of African catfish (*Clarias gariepinus*) fillets, *Archiv Lebensmittelhygiene*, **61**: 31-35.

LFGB (2008) Amtliche Sammlung von Untersuchungsverfahren nach §64 LFGB. Bestimmung des Gesamtphosphorgehaltes in Fleisch und Fleischerzeugnissen, Photometrisches Verfahren. 06.00/9. Retrieved March 15, 2013 from: **http://www.methodensammlung-bvl.de**

Mendil, D., Demirci, Z., Tuzen, M., Soylak, M., (2010). Seasonal investigation of trace element contents in commercially valuable fish species from the Black sea, Turkey, *Food and Chemical Toxicology*, **48**: 865-870.

doi: 10.1016/j.fct.2009.12.023

Mol, S., (2011a). Determination of trace metals in canned anchovies and canned rainbow trouts, *Food and Chemical Toxicology*, **49**: 348-351.

doi: 10.1016/j.fct.2010.11.005

Mol, S., (2011b). Levels of selected trace metals in canned tuna fish produced in Turkey, *Journal of Food Composition and Analysis*, **24**: 66-69.

doi: 10.1016/j.jfca.2010.04.009

Mol, S., Ozden, O., Saadet, K., (2012). Levels of selected metals in albacore (*Thunnus alalunga*, Bonnaterre, 1778) from Eastern Mediterranean, *Journal of Aquatic Food Product Technology*, **21**: 111-117.

doi: 10.1080/10498850.2011.586489

Naemmi, E.D., Ahmad, N., Al-sharrah T.K., Behbahani M., (1995). Rapid and simple method for determination of cholesterol in processed food, *Journal of AOAC International*, **78**: 1522–1525.

NMKL (Nordic Committee on Food Analysis), (2011). NMKL Protocol No. 5, Analytical Quality Control – Guidelines for the publication of analytical results of chemical analyses in foodstuffs, 23p. + 1 Annex. Retrieved March 15, 2013 from: **http://www.nmkl.org**

Oehlenschläger, J., (1995). Selengehalte im Seefischmuskel. In: *Ernährungsphysiologische Eigenschaften von Lebensmitteln*. Schriftenreihe des Bundesministeriums für Ernährung, Landwirtschaft und Forsten. Angewandte Wissenschaft, Heft 445 (pp.86-91). Münster, Germany: Landwirtschaftsverlag.

Oehlenschläger, J., (1997). Marine fish - a source for essential elements? In: J.B. Luten et al. (Eds.), *Development in food science 38. Seafood from producer to consumer, integrated approach to quality* (pp. 641-651). Amsterdam, The Netherlands: Elsevier.

Oehlenschläger, J., (1999). Gaschromatographische Bestimmung des Gesamtcholesterol-

gehaltes im verzehrbaren Anteil (Filet) von Meeresfischen und Garnelen, *Lebensmittel-chemie*, **53**: 86.

Oehlenschläger, J., (2002). Identifying heavy metals in fish. In: H.A. Bremner (Ed.), *Safety and quality issues in fish processing* (pp. 95-113). Cambridge, UK.: Woodhead.

doi: 10.1533/9781855736788.1.95

Oehlenschläger, J., (2006). Cholesterol content in seafood, data from the last decade: a review. In: J.B. Luten et al. (Eds.), *Seafood research from fish to dish: quality, safety and processing of wild and farmed fish* (pp. 41-58). Wageningen, The Netherlands. Academic Publishers.

Oehlenschläger, J., Rehbein, H., (2009). Basic facts and figures. In: H. Rehbein & J. Oehlenschläger (Eds.), *Fishery Products – Quality, safety and authenticity* (pp. 1-18). Oxford, UK: Wiley- Blackwell.

Özogul, Y., Özogul, F., Alagoz, S., (2007). Fatty acid profiles and fat contents of commercially important seawater and freshwater fish species of Turkey: A comparative study, *Food Chemistry*, **103**: 217-223.

doi: 10.1016/j.foodchem.2006.08.009

Şireli, U.T., Göncüoğlu, M., Yıldırım, Y., Gücükoğlu, A., Çakmak, Ö., (2006). Assessment of heavy metals (cadmium and lead) in vacuum packaged smoked fish species (mackerel, *Salmo salar* and *Oncorhynhus mykiss*) marketed in Ankara (Turkey), *Ege University Journal of Fisheries & Aquatic Sciences*, **23**: 353–356.

Smedes, F., (1999). Determination of total lipid using non-chlorinated solvents, *Analyst*, **124**: 1711-1718.

doi: 10.1039/A905904K

Tuzen, M., (2009). Toxic and essential trace elemental contents in fish species from the Black Sea, Turkey, *Food and Chemical Toxicology*, **47**: 1785-1790.

doi: 10.1016/j.fct.2009.04.029

Tuzen, M., Soylak, M., (2007). Determination of trace metals in canned fish marketed in Turkey, *Food Chemistry*, **101**: 1378-1382.

doi: 10.1016/j.foodchem.2006.03.044

Uluozlu, O.D., Tuzen, M., Mendil, D., Soylak, M., (2007). Trace metal content in nine species of fish from Black and Aegean Seas, Turkey, *Food Chemistry*, **104**: 835-840.

doi: 10.1016/j.foodchem.2007.01.003

Undeland, I., (2009). Selected amino acids in fish. In; Luten, J.B. (Ed.), *Marine functional food* (pp. 43-47). Wageningen, The Netherlands: Academic Publishers.

Yildirim, Y., Gonulalan, Z., Narin, I., Soylak, M., (2009). Evaluation of trace heavy metal levels of some fish species sold at retail in Kayseri, Turkey, *Environmental Monitoring and Assessment*, **149**: 223-228.

doi: 10.1007/s10661-008-0196-7

Yilmaz, A.B., Sangün, M.K., Yaglioglu, D., Turan, C., (2010). Metals (major, essential to non-essential) composition of the different tissues of three demersal fish species from Iskenderun Bay, Turkey, *Food Chemistry*, **123**: 410-415.

doi: 10.1016/j.foodchem.2010.04.057