Arch Lebensmittelhyg 66,
117–122 (2015)
DOI 10.2376/0003-925X-66-117

ISSN 0003-925X

Korrespondenzadresse:
nurerkan@istanbul.edu.tr

Istanbul University, Faculty of Fisheries, Department of the Seafood Processing and Quality Control, Ordu Caddesi No:200 Laleli 34134 Fatih/İstanbul-Turkey

Effects of different cooking and processing methods on the selenium contents of fish species

Einfluss unterschiedlicher Koch- und Verarbeitungsmethoden zum Selengehalt in Fischarten

Nuray Erkan

Summary

The study was carried out to determine the current contents of selenium in different cooked and processed fish products. Mean selenium contents in raw species ranged from 0.361 to 0.563 µg/g. The average selenium contents of cooked samples varied from 0.479 to 0.880 µg/g in grilled fish, from 0.223 to 0.750 µg/g in fried fish and from 0.361 to 0.664 µg/g in steamed fish. Selenium contents from 0.360 to 0.936 µg/g were found in smoked fish and from 0.455 to 1.786 µg/g in salted fish. Measured values are sufficient to meet the daily selenium intake and is far below the upper tolerable level of selenium.

Keywords: Fish, selenium, daily intake, cooking methods, processing methods

Zusammenfassung

Die Studie wurde durchgeführt, um die aktuelle Menge von Selen in verschiedenen gekochten und verarbeiteten Fischprodukten zu bestimmen. Durchschnittliche Selengehalte in den rohen Fischarten wurden von 0.361 bis 0.563 µg/g gefunden. Die mittleren Selengehalte von gekochten Proben variierten von 0.479 bis 0.880 µg/g in gegrilltem Fisch, von 0.223 bis 0.750 µg/g in gebratenem Fisch und von 0.361 bis 0.664 µg/g in gedämpftem Fisch. Die Menge des Selens wurde von 0.360 bis 0.936 µg/g für geräucherten Fisch und von 0.455 bis 1.786 µg/g für gesalzenen Fisch gemessen. Die Messwerte sind ausreichend, um die notwendige tägliche Selenaufnahme zu erfüllen und liegen weit unter dem oberen verträglichen Maß von Selen.

Schlüsselwörter: Fisch, Selen, tägliche Aufnahme, Koch- und Verarbeitungsmethoden

Journal of Food Safety and Food Quality 66, Heft 4 (2015), Seiten 85–124

Introduction

Seafood is high nutritional quality food item with rich polyunsaturated fatty acids in n-3 forms, essential amino acids, trace elements and vitamins, and low cholesterol and saturated fatty acids content (Erkan et al., 2010). Its consumption has been widely encouraged to prevent coronary heart disease, hypertension and cancer (Erkan and Çağıltay, 2011). Selenium (Se) is an essential trace element, and foodstuffs such as cereals, meat and fish are the principal source of Se for the general population. The best-known biochemical role of Se is its function as part of the enzyme glutathione peroxidase which protects vital components of cells against oxidative damage. It is also involved in thyroid metabolism, immune system and male fertility (Sirichakwal et al., 2005). Trace concentrations are required for normal growth and development, moderate concentrations can be stored and homeostatic functions maintained and elevated concentrations can result in toxic effects (Hamilton, 2004). Fishing plays an important role in Turkey's economy. Fish consumption per capita of Black Sea, Marmara Sea, Aegean Sea and Mediterranean Sea coastal region were significantly higher than those reported in inland region (TUIK, 2013). Anchovy, sardine, Atlantic mackerel, horse makkerel, small and medium bluefish, red mullet, hake, small and medium Atlantic Bonito, trout and eel are marine resources of major economic and gastronomic importance in Turkey and European countries. Anchovy, sardine, Atlantic mackerel, horse mackerel, red mullet, hake, small and medium Atlantic Bonito and trout is mostly consumed grilled and fried, whereas small-medium bluefish is generally boiled before consumption. Smoked salmon, smoked eel, smoked trout, marinated anchovies, salted anchovies and salted sardines are often consumed in processed sea products. Cooking and processing presents consumer different tastes. Changes of nutrient components in foods occurred due to the cooking and processing must be known since they are important for human health (Ersoy et al., 2006). Recently very valuable data have been published concerning the iodine content assessment of fresh, processed and different cooked fishes (Erkan, 2011). The aim of the study is twofold: first, to determine Se levels in muscle meat of cooked and processed fish of the main species consumed in Turkey, and to compare the results with international levels; second, to estimate the dietary intake of Se derived from this fish product consumption.

Materials and Methods

Samples

Six commercial important fish species were chosen for the study. The fish were purchased from the Istanbul local fish market and included anchovy *(Engraulis encrasicolus),* horse mackerel *(Trachurus trachurus),* small and medium bluefish *(Pomatomus saltatrix),* Atlantic Bonito *(Sarda sarda),* striped red mullet *(Mullus surmelutus),* and whiting *(Merlangius merlangus).* The fishes were prepared and cooked by frying, grilling and steaming according to common household methods. Hot-smoked fish was prepared from small and medium Atlantic Bonito *(Sarda sarda),* Atlantic mackerel *(Scombrus scombrus),* salmon *(Salmo salar),* rainbow trout *(Oncornhychus mykiss),* and eel *(Anguilla anguilla).* Salted fish (lakerda) was prepared from small and medium Atlantic Bonito *(Sarda sarda),* salted fish was prepared from sardine *(Sardine pilchardus).* Dried fish was prepared from horse mackerel *(Trachurus trachurus).* Marinated fish was prepared from anchovy *(Engraulis encrasicolus).* Canned fish was prepared from tuna *(Thunnus thynnus).* Fish were obtained from a fish market in Istanbul, Turkey. The fresh fish samples were packed in polystyrene boxes with crushed ice, and then transferred to the laboratory.

Sample preparation

The fish were beheaded, gutted (manually), and then washed with tap water several times to remove adhering blood and slime. The edible muscle was cut into pieces.

Cooking

Regarding frying, fish was previously coated with wheat flour. For frying, samples were immersed in vegetable oil at 180 °C for 10 min. After each treatment the oil was discarded. The grilling process was carried out with an electrically operated grill (1400 Watt, Tefal, France) at 180 ºC for 30–40 min. Automatic cooker (2000 Watt, Tefal, France) was used for the steaming process (10–12 min for 250 g fish).

Preparation of processed fish

- **Smoked fish:** The samples were immersed in brine at a ratio of 1:1 (w/w) for 24 h at 2 °C. The brine contained 12 % NaCl. After brining, the samples were removed from the brine, and then briefly dipped in chilled tap water for 1 h. Smoke was produced from oak sawdust. The processing time in the kiln was divided into two stages: (1) a preliminary drying and cooking period (45 min) at 75 °C; (2) a smoking and partial cooking period at 80 °C (60 min). After cooling at room temperature (60 min), the smoked fish were packaged by vacuum and stored at 2 °C.
- **Salted fish (Lakerda):** The Atlantic Bonito were dry salted for 7 days, at 4 °C (fish weight: salt weight (1:3)), and then brined in a 15 % salt solution for 10 days, at 4 °C (fish: brine ratio=1:1, w/w). Salted fish were packaged into glass jars of 500 mL capacity with 200 mL 10 % salt solution.
- **Salted fish:** The sardine were dry salted (fish weight: salt weight (1:3)) for 30 days at 4 °C.
- **Marinated fish:** Anchovy were filleted and washed. Fillets were dipped in 3 % acetic acid/10 % salt marinating solution at a ratio of 1:1.5 (w/w) for 24 h at 4 °C. After marination the fish were drained at ambient temperature (18 ± 1 °C) for 15 min, placed into glass jars of 400 mL capacity with 125 mL sun flower oil.
- **Dried fish:** The horse mackerel were dry salted for 30 days, at 4 °C (fish weight: salt weight (1:3)). Salted samples were dried in a temperature-controlled cabin (12 ± 2 °C) for 20 days.
- **Canned fish:** Tuna were filleted, washed and cooked by steam cooking. They were packeged in water and sunflower oil. After cooking and processing process, the bones and skin were removed. All fish in each lot were homogenized using a laboratory blender and analysed to determine selenium contents. All assays were conducted on duplicate samples of the homogenates.

Analytical procedure of selenium analysis

Determination of total Se was carried out with a Thermo electron X7 inductively coupled plasma mass spectrometry (ICP-MS), (Model X series, Winsford-Cheshire UK). For

each sample, between 0.3 and 0.5 g of tissue (wet weight) was weighed and placed in a Teflon digestion vessel with 7 mL of concentrated (65 %) nitric acid (HNO_3) and 1 mL 30 % hydrogen peroxide (H_2O_2). The sample in the vessel containing concentrated nitric acid was then subjected to a microwave program as follows: Step 1: 25–200 °C for 10 min at 1000 W; Step 2: 200 °C for 10 min at 1000 W. Digests were finally made up with deionized water to 25 mL in acid washed standard flasks (EPA, 1994). ICP-MS operating conditions: Nebulizer gas flow 0.91 L/min, Radio frequency (RF) 1200 W, Lens voltage 1.6 V, Cool Gas 13.0 L/min, Auxiliary Gas 0.70 L/min. Instrument detection limits on the ICP-MS were 2000 ppt for selenium. Three sub-samples of each seafood material were digested using the above method. All measurements were run in triplicate for the sample and standard solutions. Selenium concentrations were calculated in µg/g wet weight. Accuracy of analytical method was monitored by analysing certified reference materials (Mussel tissue (Catalog No: ERMI-CE278, LGC Promochem Middlesex-UK)). Data quality was checked by analysing standard reference materials. Certificated value and observed value were 1.84 ±0.10 µg/g and 1.82 ±0.13 µg/g, respectively.

Statistical analysis

The descriptive statistics (mean, standard deviation, range) were conducted using the Microsoft Office Excel 2010 software (Seattle, USA).

Results and discussion

Mean selenium levels in raw fish were 0.359 µg/g for anchovy (0.357–0.361 µg/g), 0.488 µg/g for small Atlantic Bonito (0.415–0.622 µg/g), 0.482 µg/g for medium Atlantic Bonito (0.389–0.575 µg/g), 0.545 for small bluefish, 0.428 µg/g for medium bluefish, 0.250 µg/g for eel, 0.893 µg/g for sardine, 0.600 µg/g for horse mackerel (0,563–0,637), 0,258 µg/g for rainbow trout, 0.465 µg/g for red mullet, 0.893 µg/g for sardine, 0.271 for salmon, 0.893 µg/g for sardine, 0.464 µg/g for whiting, 0.847 for tuna, 0.893 µg/g for sardine (Tab. 1). This result is similar to the Se content of Atlantic Bonito (0.021–0.593 µg/g) and of horse mackerel (0.107–0.662 µg/g) described by Özden (2010). Similar result was found by Özden et al. (2011), who studied the effect of season on selenium content. They found that the Se content in red mullet was 0.066–0.618 µg/g, while it was 0.133–0.848 µg/g in whiting. Kadrabova et al. (1997) reported Se levels of sea fish and river fish con-

TABLE 1: *The selenium content of cooked and processed fishes.*

Raw and cooked fishes	Selenium (µg/g)	The daily Se intake (µg) in cooked fish (about 200 g)	Raw and processed fishes	Selenium (µg/g)	The daily Se intake (µg) in processed fish (about 200 g)
Raw (Anchovy)	0.361 ± 0.014a	72.2	Raw (Small Atlantic Bonito)	0.622 ± 0.021a	124.4
Fried	**0.223 ± 0.014b**	**44.6**	**Smoked small Atlantic Bonito**	**0.936 ± 0.005b**	**187.2**
Grilled	**0.479 ± 0.005c**	**95.8**	Raw medium Atlantic Bonito	0.575 ± 0.011a	115
Steamed	**0.361 ± 0.080a**	**72.2**	**Smoked (Medium Atlantic Bonito)**	**0.764 ± 0.021b**	**152.8**
Raw (Horse mackerel)	0.563 ± 0.015a	112.6	Raw (Atlantic mackerel)	0.438 ± 0.013a	87.6
Fried	**0.571 ± 0.011a**	**114.2**	**Smoked (Atlantic mackerel)**	**0.788 ± 0.012b**	**157.6**
Grilled	**0.580 ± 0.009a**	**116**	Raw (Salmon)	0.271 ± 0.012a	54.2
Steamed	**0.517 ± 0.016b**	**103.4**	**Smoked salmon**	**0.405 ± 0.001b**	**81**
Raw (Small bluefish)	0.545 ± 0.014a	109	Raw (Rainbow trout)	0.258 ± 0.008a	51.6
Fried	**0.623 ± 0.008b**	**124.6**	**Smoked trout**	**0.360 ± 0.017b**	**72.0**
Grilled	**0.664 ± 0.017c**	**132.8**	Raw (Eel)	0.250 ± 0.031a	50.0
Steamed	**0.627 ± 0.011d**	**125.4**	**Smoked (Eel)**	**0.496 ± 0.022b**	**99.2**
Raw (Medium bluefish)	0.428 ± 0.002a	85.6	Raw (Small Atlantic Bonito)	0.426 ± 0.010a	85.2
Fried	**0.635 ± 0.024b**	**127**	**Salted (Small Atlantic Bonito)**	**0.615 ± 0.016b**	**123**
Grilled	**0.880 ± 0.019c**	**176**	Raw (Medium Atlantic Bonito)	0.389 ± 0.025a	77.8
Steamed	**0.536 ± 0.020d**	**107.2**	**Salted (Medium Atlantic Bonito)**	**0.455 ± 0.028b**	**91**
Raw (Small Atlantic Bonito)	0.415 ± 0.005a	83	Raw (Sardine)	0.893 ± 0.019a	178.6
Fried	**0.582 ± 0.015b**	**116.4**	**Salted (Sardine)**	**1.786 ± 0.260b**	**357.2**
Grilled	**0.653 ± 0.012c**	**130.6**	Raw (Horse mackerel)	0.637 ± 0.023a	127.4
Steamed	**0.545 ± 0.014d**	**109**	**Dried horse mackerel**	**1.281 ± 0.024b**	**256.2**
Raw (Striped red mullet)	0.465 ± 0.012a	93	Raw (anchovy)	0.357 ± 0.012a	71.4
Fried	**0.750 ± 0.001b**	**150**	**Marinated anchovy**	**0.555 ± 0.022b**	**111**
Grilled	**0.655 ± 0.017c**	**131**	Raw (Tuna)	0.847 ± 0.009a	169.4
Steamed	**0.562 ± 0.002d**	**112.4**	**Canned tuna in water**	**0.643 ± 0.015b**	**128.6**
Raw (Whiting)	0.464 ± 0.008a	92.8	Canned tuna in oil	0.656 ± 0.011b	131.2
Fried	**0.631 ± 0.008b**	**126.2**	**Mean of smoked fish**	**0.625±0.236a**	**125**
Grilled	**0.701 ± 0.005c**	**140.2**	**Mean of salted fish**	**0.952±0.727a**	**190.4**
Steamed	**0.556 ± 0.007d**	**111.2**	**Mean of dried fish**	**1.281 ± 0.024a**	**256.2**
Mean of raw fish	0.463 ± 0.071ab	92.6	Mean of marinated fish	0.555 ± 0.022a	111
Mean of fried fish	**0.574 ± 0.165a**	**114.8**	**Mean of canned fish**	**0.650 ± 0.001a**	**130**
Mean of grilled fish	**0.659 ± 0.122a**	**131.8**			
Mean of steamed fish	**0.537±0.083ab**	**107.4**			

Journal of Food Safety and Food Quality 66, Heft 4 (2015), Seiten 85–124

sumed in Slovak Republic as 0.505–0.196 µg/g. Erkan and Özden (2007) determined selenium content of sea bass (0.28 µg/g) and sea bream catfish (0.24 µg/g). This result is similar to the Se content of sea bass (0.227 µg/g) described by Satovic and Beker (2004). This value was lower than that reported by Önnig (2010) for herring (0.347 µg/g), mackerel (0.498 µg/g), turbot (0.473 µg/g), flounder (0.371 µg/g) and the value reported by Orban et al. (2000) for sea bream (1.37 µg/g). Plessi et al. (2001) reported the selenium content of angler fish (0.173 µg/g), salmon (0.353 µg/g), redfish (0.247 µg/g), and porgy (0.286 µg/g). This is in agreement with findings of Iqbal et al. (2008), who reported Se contents of Pakistani sea fishes between 0.295–0.714 µg/g. Selenium levels in the literature were reported 0.506 µg/g for bogue, 0.117 µg/g for gilthead, 0.297 µg/g for sardine and 0.627 µg/gfor trout from Greek market (Pappa et al., 2006) and 0.473 µg/g for catfish, 0.881 µg/g for makkerel, 0.523 µg/g for pomfret from Thai market (Sirichakwal et al., 2005). Se levels for fishes from Slovenian markets (Smrkolj et al., 2005) were reported between 0.153–0.686 µg/g. In the literature, fish-based foods have the highest selenium contents among all food types, with a Se content of 0.23 µg/g; 0.40 µg/g being the average (Amodia-Coccheri et al., 1995; Dashti et al., 2004). Selenium levels in fried fish were found 0.223 µg/g for anchovy, 0.571 µg/g for horse mackerel, 0.623 µg/g for small bluefish, 0.635 µg/g for medium bluefish, 0.582 µg/g for Atlantic mackerel, 0.750 µg/g for red mullet, 0.631 µg/g for whiting. The lowest and the highest Se levels in grilled samples found were 0.479 µg/g in anchovy and 0.880 µg/g in medium bluefish. The minimum and maximum selenium values of steamed samples were found as 0.361 µg/g in anchovy samples and 0.627 µg/g in small bluefish samples (see Tab. 1). The ranges of selenium in µg/g for grilled fishes in literature were reported as 0.97 µg/g for sardine (0.68–1.38 µg/g), 1.85 µg/g for horse mackerel (1.29–2.32 µg/g), 0.38 µg/g for gilthead sea bream (ND–0.61 µg/g) and 1.49 µg/g for silver scabbard fish (1.18–1.87 µg/g) (Martins et al., 2011). Selenium levels in the literature were reported 0.160 µg/g for fried fish and 0.340 µg/g for grilled fish from Australian market (Mc Naughton and Marks, 2002). The ranges of these metals in µg/g for fried fishes in literature (Martins et al., 2011) were reported as 1.28 µg/g for horse mackerel (1.12–1.46 µg/g) and 0.84 µg/g for hake (0.62–1.13 µg/g). Selenium content in the literature (Hussein and Bruggeman, 1999) ranged from 0.308 to 0.387 µg/g for muscles of fried fish from Egyptian. The ranges of Se in µg/g for boiled fish in literature were reported as 1.22 µg/g for hake (0.84–1.41 µg/g) and 0.87 µg/g for octopus (0.77–0.99 µg/g) (Dashti et al., 2004).

Selenium was found at an average level of 0.625 µg/g in smoked fish. Smoked small Atlantic Bonito and smoked Atlantic mackerel again had the highest levels of Se (0.936 and 0.788 µg/g, respectively) followed in decreasing order by smoked medium Atlantic Bonito and smoked eel (0.764 and 0.496 µg/g, respectively). The lowest selenium contents in smoked fish were 0.360 µg/g in rainbow trout (Tab. 1). Selenium levels in the literature were reported 0.632 µg/g for smoked fish from Australian market (Hussein and Bruggeman, 1999). Selenium average levels in salted fish were found 0.952 µg/g. The lowest and highest selenium contents in salted fish were in medium Atlantic Bonito (0.455 µg/g) and in sardine (1.786 µg/g). Selenium contents of dried fish were determined 1.281 µg/g. Selenium values were 0.555 µg/g and 0.643–0.656 µg/g for marinated anchovy and canned tuna, respectively. Selenium levels in the literature were reported 0.223 µg/g for canned sardine from Egyptian (Mc Naughton and Marks, 2002) and 0.571 µg/g for canned sardine, 0.859 µg/g for canned tuna from Croatia (Klapec et al., 2004), 0.70 µg/g for canned tuna in brine (Murphy and Cashman, 2001), 0.14 µg/g for canned red mullet (Tüzen and Soylak, 2007).

Generally, the increase in selenium content was not significant ($p > 0.05$) for cooked and processed samples when compared with the raw samples. The cause of the rise is in water loss during this cooking and processing. Martins et al. (2011) found an increase of selenium after cooking in grilled sardine, grilled and fried mackerel, fried hake, whereas the same publication reported a considerable decrease in the selenium content after household preparation of boiled hake. Selenium, essential mineral is necessary for good health. Selenium plays a protective role in preventing carcinogenesis and other chronic diseases (Dashti et al., 2004). There is evidence that selenium has an antioxidant role (Hartikainen, 2005). Se deficiency can lead to heart disease, hypothyroidism and a weakened immune system (Ellis and Salt, 2003; Sirichakwal et al., 2005). Selenium is necessary for health, although there may be toxic at high doses. Selenium intake of 900 µg a day for hair loss and the morphological changes in fingernails have been reported in sufficient doses. The U.K Department of Health has recommended the maximum safe Se intake from all sources to be 450 µg per day for adult males (Foster and Sumar, 1997). According to the European Food Safety Authority (2006), tolerable upper intake value is 300 µg per day for adult. The recommended intake value of selenium varies between countries. Recommended daily intake of Se in Turkey has been reported as 30 µg/day (Foster and Sumar, 1997). However, selenium requirement of adults is calculated to be 70 and 55 µg/day for males and females, respectively (RDA, 1989). A joint FAO/IAEA/WHO Expert Consultation (WHO, 1996) gave several modes for the calculation of requirements of the individual and populations. For a 65 kg reference man the average normative requirement of individuals for selenium was estimated to be 26 µg/day, and from this value the lower limit of the need of population mean intakes was estimated to be 40 µg/day. The corresponding values for a 55 kg reference woman were 21 and 30 µg selenium/day, respectively. Reference Intake of 55 µg selenium per day for adults, but also other levels of intakes based on other criteria, was established by the Scientific Committee for Food of the European Commission (1993). Bioavailability of selenium in food samples is affected by its chemical form and also other dietary factors such as total protein, fat and heavy metal contents (Bhattacharya et al., 2003). This is the first study concerning the evaluation of the effects of cooking and processing methods on selenium contents of fish species consumed in Turkey. According to this study results, with a mean fish meal consumption of 200.0 g/person/day, the average daily selenium intake was found 114.8 µg in fried fish, 131.8 µg in grilled fish and 107.4 µg in steamed fish. The highest daily intake were found as 150 µg in fried red mullet samples, 176 µg in grilled medium bluefish samples and 125.4 µg in steamed small bluefish samples. The lowest and highest daily selenium intakes for processed fish products were found as 81 µg in smoked salmon and 357.2 µg in salted sardine samples. Mean daily selenium intake was found of smoked fish and canned fish (125 µg and 130 µg). This value agrees well with the recommended nutrient intake for adults proposed by FAO

(2001) (25–34 µg/day) and by FSA (2003) (60–75 µg/day). It is also far below the upper tolerable nutrient level of 400 µg/day (FAO, 2001).

Conclusions

In this study, the selenium content of consumption preferred and economically important of fishes was found similar to the literature data. The applied different cooking and processing techniques showed positive effects in the selenium content of these fishes. Measured values is more than sufficient to meet the daily selenium intake values and is far below the tolerable upper intake value of selenium. This is the first study concerning the evaluation of the effects of cooking and processing methods on selenium contents of fish species consumed in Turkey.

Acknowledgments

This work was supported by the Research Found of Istanbul University, Project Number BYP-16966 and UDP 43971.

Conflict of interest

I certify that there is no potential conflict of interest in relation to this article.

References

Amodia-Coccheri R, Arnese A, Roncioni A, Silvestri G (1995): Evaluation of the selenium content of the traditional Italian diet. Int J Food Sci Nutr 46: 149–154.

Bhattacharya B, Sarkar SK, Das R (2003): Seasonal variations and inherent variability of selenium in marine biota of a tropical wetland ecosystem: implications for bioindicator species. Ecol Indic 2: 367–375.

Dashti B, Al-Awadi F, Al-Kandari R, Ali A, Al-Otaibi J (2004): Macro- and microelements content of 32 Kuwaiti composite dishes. Food Chem 85(3): 331–337.

Ellis DR, Salt DE (2003): Plants, selenium and human health. Curr Opin Plant Bio 6: 273–279.

Environmental Protection Agency (EPA) (1994): Microwave assisted acid digestion of sediments, sludges, soils, and oils. Method 3051.

Erkan N (2011): Iodine content of cooked and processed fish in Turkey. Int J Food Sci Technol 46: 1734–1738.

Erkan N, Çağıltay F (2011): The effect of cultural factors and consumer knowledge on fish consumption. Food Eng Ingr 36: 42–45.

Erkan N, Özden Ö (2007): Proximate composition and mineral contents in aqua cultured sea bass *(Dicentrarchus labrax),* sea bream *(Sparus aurata)* analyzed by ICP-MS. Food Chem 102(3): 721–725.

Erkan N, Özden Ö, Selçuk A (2010): Effect of Frying, Grilling, and Steaming on Amino Acid Composition of Marine Fishes. J Med Food 13(6): 1524–1531.

Ersoy B, Yanar Y, Küçükgülmez A, Çelik M (2006): Effects of four cooking methods on the heavy metal concentrations of sea bass fillets (*Dicentrarchus labrax* – Linne, 1785). Food Chem 99: 748–751.

European Food Safety Authority (2006): Scientific Committee on Food Scientific Panel on Dietetic Products, Nutrition and Allergies. Tolerable Upper Intake Levels.

Food and Agriculture Organization (FAO) (2001): Human vitamin and mineral requirements, Food and Nutrition Division. Available from: URL http://whqlibdoc.who.int/publications/2004/9241546123.pdf (visit 05.02.2015).

Food Standard Agency (FSA) (2003): Risk Assessment-Selenium. Expert Group on Vitamins and Minerals, Available from: URL http://www.food.gov.uk/multimedia/pdfs/evm_selenium.pdf (visit 05.02.2015).

Foster LH, Sumar S (1997): Selenium in health and disease: a review. Crit Rev Food Sci Nutr 37(3): 211–228.

Hamilton SJ (2004): Review of selenium toxicity in the aquatic food chain. Sci Total Environ 326: 1–31.

Hartikainen H (2005): Biogeochemistry of selenium and its impact on food chain quality and human health. J Trace Elem Med Biol 18: 309–318.

Hussein L, Bruggeman J (1999): Selenium analysis of selected Egyptian foods and estimated daily intakes among a population group. Food Chem 65: 527–532.

Kadrabova J, Madaric A, Ginter E (1997): The selenium content of selected food from the Slovak Republic. Food Chem 58 (1–2): 29–32.

Klapec T, Mandic ML, Grgic J, Primorac L, Perl A, Krstanovic V (2004): Selenium in selected foods grown or purchased in eastern Croatia. Food Chem 85: 445–452.

Iqbal S, Kazi TG, Bhanger MI, Akhtar M, Sarfraz RA (2008): Determination of selenium content in selected Pakistani foods. Int J Food Sci Technol 43: 339–345.

Martins CT, Almeida CMM, Alvito PC (2011): Selenium Content of Raw and Cooked Marine Species Consumed in Portugal. Food Anal Method 4: 77–83.

Mc Naughton SA, Marks GC (2002): Selenium Content of Australian Foods: A Review of Literature Values. J Food Compost Anal 15: 169–182.

Murphy J, Cashman KD (2001): Selenium content of a range of Irish foods. Food Chem 74: 493–498.

Orban E, Di Lena G, Ricelli A, Paoletti F, Casini I, Gambelli L, Caproni R (2000): Quality characteristics of sharp snout sea bream *(Diplodus puntazzo)* from different intensive rearing systems. Food Chem 70(1): 27–32.

Önnig G (2000): Separation of soluble selenium compounds in different fish species. Food Chem 68: 133–139.

Özden Ö (2010): Micro, macro mineral and proximate composition of Atlantic bonito and horse mackerel: A monthly differentiation. Int J Food Sci Technol 45: 578–586.

Özden Ö, Erkan N, Ulusoy Ş (2010): Determination of mineral composition of in three commercial fish species (*Solea solea, Mullus surmuletus,* and *Merlangius merlangus*). Environ Monit Assess 170: 353–363.

Pappa EC, Pappas AC, Surai PF (2006): Selenium content in selected foods from the Greek market and estimation of the daily intake. Sci Total Environ 372: 100–108.

Plessi M, Bertelli D, Monzani A (2001): Mercury and selenium content in selected seafood. J Food Comp Anal 14: 461–467.

Recommended Dietary Allowance (RDA) (1989): Recommended dietary allowance (10th ed.). Washington, DC: National Academic Press.

Satovic V, Beker D (2004): Selenium content in sea bass of the Adriatic Sea. Euro Food Res and Techn 218: 111–113.

Journal of Food Safety and Food Quality 66, Heft 4 (2015), Seiten 85–124

Scientific Committee for Food of the European Commission (1993): Commission of the European Communities. Reports of the Scientific Committee for Food of the European Community. Thirty-first series. Nutrient and energy intakes for the European Community. Commission of the European Communities, Luxembourg.

Sirichakwal PP, Puwastien P, Polngam J, Kongkachuichai R (2005): Selenium content of Thai foods. J Food Comp Anal 18(1): 47–59.

Smrkolj P, Pograjc L, Hlastan-Ribič C, Stibilj V (2005): Selenium content in selected Slovenian foodstuffs and estimated daily intakes of selenium. Food Chem 90(4): 691–697.

Türkiye Istatistik Kurumu (TUIK) (2013): Fishery Statistics, http://www.tuik.gov.tr/Kitap.do?metod=KitapDetay&KT_ID=13&KITAP_ID=52 (visit 02/02/2014)

Tüzen M, Soylak M (2007): Evaluation of trace element contents in canned foods marketed from Turkey. Food Chem 102: 1089–1095.

World Health Organisation (WHO) (1996): Trace elements in human nutrition and health. WHO, Geneva.

Address of corresponding author:
Nuray Erkan
Istanbul University, Faculty of Fisheries,
Department of the Seafood Processing
and Quality Control,
Ordu Caddesi No:200 Laleli 34134 Fatih/İstanbul-Turkey
nurerkan@istanbul.edu.tr

+++ Nachrichten aus Forschung, Politik und Industrie +++

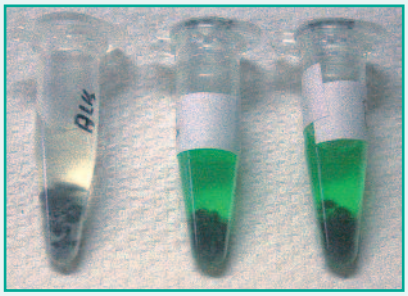
(Die Verantwortlichkeit für die Texte liegt ausschließlich bei den Instituten, Ministerien und werbenden Unternehmen.)

Falscher Kaviar aus Bulgarien und Rumänien

Ein erheblicher Teil des in Bulgarien und Rumänien verkauften Kaviars wird mit falschem Etikett verkauft oder ist sogar gefälscht. Dies fanden Forscher des Leibniz-Instituts für Zoo- und Wildtierforschung (IZW) und des WWF Österreich durch eine Marktuntersuchung heraus. Die Studie wurde jetzt in dem wissenschaftlichen Fachmagazin Journal of Applied Ichthyology veröffentlicht.

Analysen von 27 Kaviarproben aus Rumänien und Bulgarien ergaben, dass die Anzahl an Kaviardosen, die mit falschem oder überhaupt keinem Etikett zum Verkauf angeboten werden, unerwartet hoch ist. Eigentlich müssen alle Kaviargläser und -dosen durch einen universellen Etikettierungscode gekennzeichnet sein, welcher die wichtigsten Informationen über die Herkunft des Kaviars, z. B. Störart, Aquakultur oder Wildfang und Herkunftsland, angibt. In sieben Fällen wurde der Kaviar jedoch illegal ohne Etikett von Straßenverkäufern oder in Geschäften verkauft. Durch genetische Analysen wurde bei allen Kaviarproben die Störart bestimmt. Unter den etikettierten Dosen stimmten lediglich zehn Proben mit der angegeben Art überein. Vier Proben enthielten Kaviar von einer anderen bzw. mehreren, nicht auf dem Etikett genannten Störarten. Bei mindestens einer der falsch etikettierten Kaviardosen wurde der Kaviar von einer preiswerteren zu einer teureren Art aufgewertet. Sechs Proben waren gefälscht. Drei dieser Fälschungen enthielten überhaupt keine tierische DNA und wurden wohl gänzlich künstlich erzeugt. Eine Probe stammte vom Seehasen *(Cyclopterus lumpus),* dessen Eier allgemein als Kaviarersatz verkauft werden. Die anderen beiden Fälschungen sind höchstwahrscheinlich aus Störfleisch hergestellt worden.

„Besonders besorgniserregend für den Schutz der Störe waren vier Proben, die im Restaurant oder von Straßenverkäufern explizit als Kaviar von wilden Donau-Stören angeboten wurden. Die Fische wurden also illegal gefangen“, sagt Arne Ludwig vom Leibniz-Institut für Zoo- und Wildtierforschung (IZW). Der Kaviar stammte von dem stark gefährdeten Beluga-Stör *(Huso huso),* dessen Population im Donaudelta wahrscheinlich kurz vor dem Aussterben steht. „Ein wirkungsvoller Schutz der Störe ist nur möglich, wenn Wilderei und illegaler Handel endlich gestoppt werden“, ergänzt Jutta Jahrl vom WWF Österreich.



Aufbereitung von Kaviarproben mit Alkohol für eine genetische Analyse. Bei den gefälschten Proben BG1 und BG3 tritt künstliche grüne Farbe aus. Links sieht man eine Original-Kaviarprobe mit dem gleichen Verfahren behandelt ohne Abfärbung. Foto: Ida Steie

Echter Kaviar ist eines der teuersten Tierprodukte im weltweiten Handel und wird von Stören und Löffelstören entnommen. Der Preis des Kaviars hängt stark von der Herkunftsart ab, wobei der teuerste Kaviar vom Beluga-Stör stammt. Die Wilderei stellt weltweit eine große Bedrohung für das Überleben der Störe dar. Laut Einschätzung der Weltnaturschutzvereinigung (IUCN) von 2009 sind Störe die weltweit am stärksten gefährdete Tiergruppe. Alle 27 Stör- und Löffelstörarten wurden in die Liste des Übereinkommens über den internationalen Handel mit gefährdeten Arten freilebender Tiere und Pflanzen (CITES) aufgenommen, um sie vor illegalem Handel zu schützen. Dadurch soll jeder internationale Handel von Störexemplaren, -teilen oder -produkten kontrolliert werden, was auch das oben beschriebene Etikettierungssystem beinhaltet. Die relativ hohe Anzahl an falsch etikettierten Kaviardosen wirft jedoch Zweifel an der Effizienz des CITES-Kennzeichnungssystems und dessen Kontrolle auf.

„Rumänien und Bulgarien sind die einzigen Länder der Europäischen Union, in denen noch immer wildlebende Störpopulationen, z. B. im Schwarzen Meer oder in der Donau, vorkommen“, berichtet Harald Rosenthal, Präsident der World Sturgeon Conservation Society (WSCS). Zwar gibt es in beiden Ländern Fang- und Handelsverbote, jedoch hält offensichtlich die illegale Fischerei weiterhin an. „Die Ergebnisse der Studie verdeutlichen die Schwäche des Störschutzes in Rumänien und Bulgarien. Wir empfehlen daher, den Schutz und die Kontrollmaßnahmen zu verstärken“, betont Arne Ludwig. Er und seine Kollegen plädieren dafür, DNA-Kontrollen von Kaviar intensiver durchzuführen und dabei auch Dosen mit scheinbar korrektem Etikett einzubeziehen.

Weitere Informationen (Quelle):
Leibniz-Institut für Zoo und Wildtierforschung (IZW)
im Forschungsverbund Berlin e. V.
www.fv-berlin.de