Arch Lebensmittelhyg 70,
149–155 (2019)
DOI 10.2376/0003-925X-70-149

ISSN 0003-925X

Korrespondenzadresse:
omer.alper.erdem@ege.edu.tr

[1]) Ege University, Faculty of Fisheries, Department of Fish Capturing and Fish Processing Technology, Section of Fish Processing Technology, Room:311 P.Code.35100 Bornova, Izmir, Turkey; [2]) Ege University, Faculty of Fisheries, Department of Fish Capturing and Fish Processing Technology, Section of Fish Processing Technology, Room:310 P.Code.35100 Bornova, Izmir, Turkey

Evaluation of nutritional, physical and sensory properties of flathead grey mullet's *(Mugil cephalus)* flesh after cooking

Untersuchung der ernährungsphysiologischen, physikalischen und sensorischen Eigenschaften von Großkopfmeeräschen-Filets (Mugil cephalus) nach dem Garen

Ömer Alper Erdem[1]), Mehmet Tolga Dincer[2])

Summary

In this study, effects of various cooking techniques (oven-baking, grilling, pan-frying) on proximate composition, fatty acids content, colour values, texture and sensory properties of flathead grey mullet *(Mugil cephalus)* were investigated. Flathead grey mullet fillets were cooked according to common consumer preferences; oven baked, pan-fried in sunflower oil and grilled. Fatty acid composition has been analysed after each technique in order to determine the most appropriate cooking method that protected levels of long chain polyunsaturated omega-3 fatty acids. In each of the three cooking techniques, loss of omega-3 fatty acids was observed, particularly in EPA (Eicosapentaenoic Acid) content. Because of the frying media, exhibiting high Linoleic Acid content, an increase in the total PUFA (polyunsaturated fatty acids) content was observed in pan-fried samples. An important effect of heat on grilled samples was that no EPA could be preserved. On the other hand, oven baking turned out to represent the optimal cooking technique regarding textural, nutritional and sensorial properties.

Keywords: Flathead grey mullet, cooking, fatty acids, texture, nutritional value

Zusammenfassung

Untersucht wurde der Einfluss verschiedener Gartechniken (Backofen, Grill, Pfanne) auf die chemische Zusammensetzung, die Fettsäure-Zusammensetzung, den Farbwert, die Textur und die sensorischen Eigenschaften von Filets der „Großkopfmeeräsche". Großkopfmeeräschen-Filets wurden entsprechend allgemeiner Vorlieben zubereitet: im Ofen gebacken, in der Pfanne mit Sonnenblumenkernöl gebraten sowie gegrillt. Die Fettsäure-Zusammensetzung wurde analysiert um die Zubereitungsart zu bestimmen, die Nährwerte optimal erhält, speziell in Hinsicht auf langkettige und mehrfach ungesättigte Omega-3-Fettsäuren. Bei allen drei Zubereitungstechniken wurden Verluste an Omega-3 Fettsäuren beobachtet, besonders im EPA (Eicosapentaensäure)-Gehalt. Aufgrund des hohen Linolsäure-Gehalts im Frittieröl wurde auch ein hoher Gehalt an PUFA in den entsprechenden Proben festgestellt. Bei den Grillproben war zu beobachten, dass der EPA-Gehalt nicht erhalten werden konnte. Auf der anderen Seite erwies sich die Zubereitung im Ofen in Hinsicht auf Textur, Nährwert und sensorische Eigenschaften als optimal und am gesundesten.

Schlüsselwörter: Großkopfmeeräsche, Kochen, Fettsäure, Textur, chemische Zusammensetzung

Introduction

As is well known, fish and seafood are important protein and lipid sources in human diet. Fish is preferred to be consumed because of its good quality protein amount it contains and its low content of saturated fatty acids (SFA) and especially because of its high content of omega-3 polyunsaturated fatty acids (PUFA), which are not intrinsically found in human body. Consuming fish can also be useful for cognitive performance of school-age children (Stonehouse 2014), as well as for reducing the potential risk of cardiovascular diseases in adults (Zheng et al. 2012).

It is common practice to cook fish and seafood before consumption. In addition to providing food hygiene and safety, this heat treatment is an important precaution to ensure that provides food, texture, flavour and colour during the cooking process during the cooking process or during the food production process. The preferred cooking methods for seafood are; baking, steaming, boiling, grilling, pan or deep-frying, and microwaving (Rosa et al. 2007; Stephen et al. 2010; Nieva-Echevarria et al. 2018; Uran and Gokoglu 2014). Different heating temperatures can vary in degeneration or degradation of intramuscular proteins at various levels and may cause organizational differences in tissue and sensory qualities (Palka and Daun 1999). The temperature used in cooking methods generally affects the nutritional value of fish, flavour compounds and notably PUFA. Effects of different cooking have been notified for some fish species including sardine (Garcia-Arias et al. 2003), cod (Sioen et al. 2006), humpback salmon (Gladyshev et al. 2006), African catfish (Rosa et al. 2007), gilthead seabream (Ozogul et al. 2009), king salmon (Larsen et al. 2010), skipjack tuna (Stephen et al. 2010), grass carp (Zhang et al. 2013), hake (Pérez-Palacios et al. 2013), anchovy (Uran and Gokoglu 2014), chinook salmon (Neff et al. 2014), common carp (Neff et al. 2014), rainbow trout (Jafarpour et al. 2015), and European seabass (Nieva-Echevarria et al. 2018) in previous studies. Most of these studies were related to the species, which have high commercial value, high omega 3 fatty acids contents and/or large quantity production by cultured/ captured. As the focus of the current study Flathead grey mullet was selected which is a quite out of target.

Flathead grey mullet *(Mugil cephalus)* shows wide geographic distribution all around the world (Pacific, Indian, and Atlantic Ocean including Mediterranean and Black Sea). It can be found especially in coastal waters, rivers, lagoons, harbours and estuaries (Ameur et al. 2012). It has a tolerance against salinity and temperature, a feature gives the chance to live in the lagoon areas. Most of the flathead grey mullet fry used in commercial aquaculture are collected from the wild full-scale commercial production of this species is not yet common. Total *Mugil cephalus* production (captured 141939 and aquacultured 13682 tonnes) was recorded as 155 621 tonnes with a value exceeding USD 70 millions in 2016 (FAO Statistics 2018).

The flathead grey mullet is one of the economically important mullet species because of its nutritional value and roe (Sengor et al. 2003). Its low price can be the advantage for the preference of the customer but its roe may sometimes have a higher price than its body.

Generally, consumers prefer frying and baking as a cooking method for this species. However, there is a lack in the knowledge about the method to be used in order to get the optimal nutritional value. The aim of this study was to determine the effects of different cooking techniques on nutritional value of flathead grey mullet flesh.

Material and methods

Flathead grey mullet

Flathead grey mullet *(Mugil cephalus)* samples were obtained from local fisherman (Homa Lagoon of Faculty of Fisheries, Ege University) during the harvesting season in September 2017. Twenty-five specimens were purchased, and kept in a polystyrene box with ice to preserve the cold chain during the transportation to the laboratory. Biometrical measurements of samples were recorded as follows: Total weight (TW) 892.77±64.00 g; total length (TL) 44.47±1.47 cm; caudal fin length (CFL) 40.93±1.35 cm; standard length (SL) 37.40±1.05 cm; body max height (BMH) 8.10±0.46 cm; body width (BW) 6.33±0.15 cm; head length (HL) 7.50±0.46 cm. Total yield value was calculated as 42,54±3,77 %.

Cooking Methods

After gutting skinless fillets were cooked by using three different cooking techniques; oven-baking, grilling and frying. Thirteen fillets were treated by each cooking technique, and uncooked ten fillets were used as raw material.

The treatment for the first group was as follows; the oven was preheated to 200 °C. The flathead grey mullet fillets were put on a baking paper and placed into the oven (Arçelik, Model SUF 3000, Bolu, Turkey). Cooking time was set to 15 minutes and upper and lower resistant heat mode cooking version was selected. As for the second group, the grill part of the oven was set 300°C (upper part) and preheating was done. Fillets were put onto a grilling tray and 5 minutes cooking time were used for each side of the fillets. After cooking, samples were placed on the kitchen countertop for cooling. The third group was the fried; 100 ml of sunflower oil was put into a frying pan and the temperature of the hot plate was set 185 °C and preheated to reach the set temperature. For each side of the fillets 4 minutes frying time was used. After frying, fillets were taken from the pan. The surface oil was taken by a pieces of napkin. All groups were placed on the kitchen countertop for 15 minutes until cooling down to room temperature.

Cooking loss

Cooking loss values were calculated using a formulation which was based on differences in the weight of samples before and after cooking.

Proximate Composition

The technique of of Bligh and Dyer (1959) was carried out to determine crude oil content of flathead grey mullets. The method of Ludorff and Meyer (1973) was used to determine moisture and ash content. The crude protein in the study was determined by using AOAC method (1995).

Colour measurements

Colour measurement was performed using the method of Schubring (2002) with measuring ten specific points from both the raw and the cooked fillet surfaces. In CIELAB, the value scale is as follows; L^* shows the intensity of black light on scales from 0 to 100 and can be expressed as brightness; When a^* gives a positive value refers red color and when giving a negative value refers to a green colour level. On the other hand, for b^* value, the positive value defines the yellow colour and the negative value indicates the blue color level.

Texture profile analysis (TPA)

Texture Profile Analysis was carried out using the TA-XT Plus texture analyzer (Stable Micro Systems, Godalming, UK) according to Schubring (2003) method. Samples were taken by using sampling apparatus (2cm diameter) and they were drawn into a cylindrical probe. The samples were compressed twice. One or two pieces were removed from the dorsal part (close to head) for each fillet. The mechanical properties of hardness, springiness, resilience, cohesiveness, chewiness and adhesiveness were evaluated from the resulting force/deformation curves. Ten measurements were taken for each group.

Fatty Acid Analysis and Atherogenicity Index (AI) and Thrombogenicity Index (TI)

Fatty acid contents of fat extracted from the samples were detected by GC. Methyl esters were confected by trans-methylation using 2 M KOH in methanol and n-heptane according to the method by Ichihara et al. (1996), and HP-Agilent 6890 (Santa Clara, CA, USA) model gas chromatography (GC) was used for the measurements. The GC analyses were performed in triplicate, and the results were expressed as % of total FAME area as the mean value of a percentage.

Using equations described by Ulbricht and Southgate (1991), the atherogenic and thrombogenic indices (AI and TI, respectively) in cooked samples were calculated to measure the possible level for preventing the appearance of micro and macro coronary diseases in cooked samples. On the other hand, to determine the healthiness priority of cooking technique, the formula below was used.

$$Atherogenic\ index = \frac{[(12{:}0) + (4 \times 14{:}0) + (16{:}0)]}{[\sum MUFA + \sum PUFA(n-6) + (n-3)]}$$

$$Thrombogenic\ index = \frac{[(14{:}0) + (16{:}0) + (18{:}0)]}{\left[\begin{array}{c}(0.5 \times \sum MUFA) + (0.5 \times \sum PUFA(n-6)) + \\ (3 \times \sum PUFA(n-3)) + \left(\frac{n-3}{n-6}\right)\end{array}\right]}$$

Sensory analysis

The method reported by Carbonell et al. (2002) was carried out by five evaluators familiar with the sensory evaluation of fish products. Cooked fillets were cut in to 6 × 3 cm pieces and placed onto plates. For each panellist, three different plates, including 3 equal pieces of each sample were served. During the evaluations major sensory criteria, namely, odour, appearance, flavour, texture and general acceptance were evaluated as by the panellists. The assessors were also asked to specify sub parameters on fourteen sensory features. Attributes were evaluated using a five-point intensity scale (1=weak and 5=intense) by the panellists.

Statistical Analysis

SPSS 20 programme was used to determine the significant differences between the mean values of the different outcomes. One-Way ANOVA followed by Tukey and Duncan tests was used for analysing differences between averages. Results were presented as means ± Stdev. The significance was determined as P<0.05 in different cooking techniques and uncooked group.

Results and discussion

Cooking loss

Cooking loss is known as the level of shrinkage of fish during cooking. The total loss during the cooking of flesh includes the losses known as droplets and volatile losses. The majority of volatile losses can be described as losses that occur as a result of water evaporation. However, this is not the only reason for the cooking loss. The main cause can be the steric effect in the muscle. This loss may also be including the oil decomposition and volatile aromatic compounds. Drips contain oil, water, salts, and nitrogen and nitrogen free extracts, all of which are directly related to heat grade and processing time. Cooking loss mean values' of oven-baked, grilled and pan-fried flathead grey mullets were measured as follows; 22.47%, 15.16% and 19.13%, respectively.

Heat may affect the shape and conformation of the proteins in fish flesh. This conformational change generally causes them to change their ability to bind and their water holding capacity as well as making them lose the ability to bind and hold onto water (Rowe and Kerth 2013). This loss of ability causes cooking loss. In the current study, the role of cooking method in the amount of cooking loss and the highest loss was observed in the oven-baked group.

Proximate Composition

Proximate composition of uncooked flathead grey mullet samples (control group) were determined as follows (%); crude fat 2.70±0.39, moisture, 77.35±0.03, ash 1.40±0.02 and crude protein 16.81±0.08. Cooking methods and used temperatures affected the proximate composition values of mullet flesh. The crude protein changes in the cooked fish muscle can be seen in Table 1. As is known, in thermal treatment over 60°C, water-soluble proteins and myofibrillar proteins may completely form gel structure in muscle because of denaturation. In the current study, heat temperatures of 185°C and 300°C of were used in different cooking techniques and in consequence of these differences, the effects of the used media could be accepted as the other reason. These effects could be especially seen in the inverse correlation of moisture and crude oil values in the fried group. In this group absorption of frying media (sunflower oil) can be another reason which explains the highest (P<0.05). result in crude fat value. Moisture content of the fried groups was determined to be significantly different and it was a lot lower than the other groups. Similar results were also observed in previous studies (Gladyshev et al. 2006; Turkkan, et al. 2008). Although the used temperature was higher in grilling technique, the loss in mo-

TABLE 1: *Proximate composition differences of the samples related to cooking techniques.*

Groups	Moisture (%)	Crude protein (%)	Crude oil (%)	Ash (%)
Oven baked	70.65±0.87[a]	21.88±1.24[a]	3.40±0.27[a]	1.68±0.03[a]
Grilled	68.37±1.01[a]	23.88±0.26[ab]	3.95±0.03[a]	2.06±0.54[a]
Fried	63.04±1.22[b]	25.90±1.05[b]	7.62±0.41[b]	1.95±0.19[a]

x±stdev, n=3. Different superscript letters in the same column indicate significant differences (P < 0.05).

TABLE 2: *Colour difference of the samples related to cooking techniques.*

Groups	L*	a*	b*
Raw	38.33±3.39[a]	–2.30±0.74[a]	3.33±0.97[a]
Oven-baked	75.30±3.94[b]	1.13±0.68[b]	18.98±5.69[bc]
Grilled	76.08±7.85[b]	–1.95±0.52[a]	17.50±1.51[b]
Pan-fried	73.77±2.93[b]	0.75±0.54[b]	23.32±3.46[c]

x±stdev, n=10. Different superscript letters in the same column indicate significant differences (P < 0.05).

isture was determined lower (P<0.05) than frying. This can be the explained by the absorption of oil from the frying media (immigration of oil).

Colour measurement

As mentioned before colour data were taken from the surface of raw and cooked samples. Colour values of raw and cooked samples can be seen in Table 2.

No statistical difference (P<0.05) was determined between cooked samples for brightness parameter *L**. However, the effect of heat treatments significantly increased (P<0.05) *L** values when compared with the raw (uncooked) fillets. In the study of Pérez-Palacios et al. (2013) *L** values of sunflower fried and oven baked hake fillets were found to be statistically the same (P>0.05). Similar results were also seen in the current study. No significant difference was determined in cooked samples (P>0.05).

Parallel results were also seen on the values of *b** parameter and samples became yellower when compared with the raw fillets. When oven baked and fried samples were found similar (P>0.05) grilled samples were significantly determined lower (P<0.05)in *a** value. This may also be the reason for used temperature in grilling process. In a previous study of Jafarpour et al. (2015) with a similar result, when compared with autoclaved and microwaved fillet samples, the highest colour change was observed in grilled rainbow trout fillets. b* value of pan-fried mullet fillets was found to be higher than the ones cooked by other techniques.

Texture Profile Analysis results

Texture is an important parameter for the consumers' preference and is directly affected by protein and water content of the samples. In the current study, correlated motions were seen for textural parameters and proximate composition changes. Table 3 shows the results of texture profile analysis results of raw and the cooked samples.

When the heat is applied, the actinomycin complex (cellular contractile proteins) becomes a denser complex than a soft gel, while the collagen proteins (Castro et al. 2015), which are responsible for protecting the structure of the fish filet, are gelatinized; so that fish fillets have a harder structure (Dunajski 1980). These changes are shown in the observed increase in hardness and chewiness parameters, but except, baked and grilled cohesiveness and resilience values, no significant statistical difference was determined between the cooked samples (P>0.05). Similar textural results were also observed in the study of Lazo et al. (2017) in flathead grey mullet samples. Hardness value of grilled flathead grey mullet was higher than value of oven-baked samples. Bainy et al. (2015) also reported similar results between grilled and baked tilapia burgers. Uran and Gokoglu (2014) reported that grilled anchovy was harder than pan-fried anchovy because anchovy flesh becomes tender by the increase in fat content. However, flathead grey mullet fillets may be less affected because of thickness of the tissue.

TABLE 3: *TPA difference of the samples related to cooking techniques.*

Samples	Hardness	Adhesiveness	Springiness	Cohesiveness	Chewiness	Resilience
Raw	1440±194^{a}	–17.02±9.95^{a}	0.23±0.03^{a}	0.20±0.02^{a}	75.53±31.93^{a}	0.09±0.01^{ab}
Oven-baked	3632±1089^{ab}	–16.04±11.48^{a}	0.26±0.03^{ab}	0.32±0.03^{b}	307.33±109.37^{ab}	0.10±0.01^{a}
Grilled	3855±1460^{b}	–9.17±5.11^{a}	0.26±0.04^{ab}	0.24±0.04^{ac}	257.77±135.09^{ab}	0.08±0.02^{b}
Pan-fried	4594±1873^{b}	–6.84±3.71^{a}	0.32±0.06^{b}	0.29±0.04^{bc}	455.07±254.37^{b}	0.09±0.01^{ab}

x±stdev, n=10. Different superscript letters in the same column indicate significant differences (P < 0.05).

Fatty acid composition

Fatty acid composition results of the raw and cooked samples can be seen in Table 4.

The most abundant fatty acid found in raw and cooked samples of flathead grey mullet fillets was palmitic acid

TABLE 4: *Fatty acid compositional changes of the samples related to cooking techniques.*

Fatty acids (%)	Raw	Oven baked	Grilled	Pan-fried
C12:0	0.04±0.00^{a}	0.08±0.01^{a}	0.04±0.00^{a}	0.06±0.00^{a}
C13:0	0.06±0.00^{a}	0.09±0.01^{a}	0.06±0.00^{a}	0.04±0.00^{a}
C14:0	7.39±0.16^{a}	4.76±0.17^{b}	7.75±0.03^{c}	6.34±0.09^{d}
C15:0	3.34±0.07^{a}	6.71±0.25^{b}	3.65±0.01^{c}	2.40±0.02^{d}
C16:0	30.40±0.67^{a}	38.73±1.52^{b}	33.78±0.14^{c}	26.46±0.15^{d}
C17:0	0.48±0.01^{a}	1.36±0.06^{b}	0.58±0.00^{c}	0.52±0.00^{ac}
C18:0	1.95±0.05^{a}	5.77±0.24^{b}	3.14±0.01^{c}	3.14±0.02^{c}
C20:0	0.10±0.01^{a}	0.13±0.01^{a}	0.15±0.02^{a}	0.14±0.12^{a}
C22:0	0.00±0.00^{a}	0.07±0.01^{b}	0.09±0.02^{b}	0.22±0.01^{c}
C23:0	1.06±0.02^{a}	1.13±0.01^{b}	1.23±0.06^{c}	1.02±0.01^{a}
C24:0	0.06±0.01^{a}	0.06±0.01^{a}	0.09±0.00^{b}	0.11±0.00^{b}
Total SFA	**44.88±0.99^{a}**	**58.89±2.24^{b}**	**50.55±0.10^{c}**	**40.44±0.23^{d}**
C14:1	0.09±0.01^{a}	0.09±0.00^{a}	0.12±0.00^{b}	0.07±0.00^{c}
C16:1	26.10±0.57^{a}	10.48±0.40^{b}	27.28±0.12^{c}	16.51±0.10^{d}
C18:1n9t	0.21±0.01^{a}	0.36±0.01^{b}	0.22±0.01^{a}	0.14±0.02^{c}
C18:1n9c	6.43±0.04^{a}	9.19±0.44^{b}	7.85±0.21^{c}	11.45±0.05^{d}
C20:1	0.47±0.02^{a}	0.45±0.03^{ab}	0.50±0.02^{b}	0.46±0.01^{a}
C22:1n9	0.15±0.01^{a}	0.10±0.00^{b}	0.15±0.01^{a}	0.09±0.01^{b}
C24:1	0.04±0.00^{a}	0.05±0.01^{a}	0.04±0.01^{a}	0.04±0.00^{a}
Total MUFA	**33.48±1.42^{a}**	**20.72±0.88^{b}**	**36.17±0.10^{c}**	**28.77±0.06^{d}**
C18:2n6t	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
C18:2n6c	2.25±0.04^{a}	3.76±0.16^{b}	5.37±0.05^{c}	11.96±0.04^{d}
C18:3n6	0.97±0.02^{a}	1.07±0.03^{b}	0.97±0.01^{a}	0.84±0.01^{c}
C18:3n3	1.84±0.04^{a}	4.37±3.78^{b}	2.17±0.02^{c}	2.63±0.01^{d}
C20:2	0.13±0.02^{a}	0.23±0.01^{b}	0.00±0.00^{c}	0.17±0.02^{a}
C20:3n6	0.21±0.00^{a}	0.20±0.01^{a}	0.23±0.00^{b}	0.19±0.02^{a}
C20:3n3	0.20±0.00^{a}	0.71±0.04^{b}	0.26±0.01^{c}	0.29±0.01^{d}
C20:5 n-3	13.24±0.29^{a}	5.27±0.21^{b}	0.00±0.00^{c}	10.88±0.10^{d}
C22:6 n-3	2.81±0.07^{a}	4.78±0.21^{b}	4.29±0.05^{c}	3.83±0.06^{d}
Total PUFA	**21.64±0.44^{a}**	**20.39±3.12^{a}**	**13.28±0.14^{b}**	**30.80±0.24^{c}**
PUFA/SFA	**0.48±0.00^{a}**	**0.34±0.00^{b}**	**0.26±0,00^{c}**	**0.76±0,00^{d}**
Σn6	**3.42±0.01^{a}**	**5.03±0.05^{b}**	**6.57±0.02^{c}**	**12.99±0.02^{d}**
Σn3	**18.08±0.10^{a}**	**15.12±1.05^{b}**	**6.71±0.02^{c}**	**17.64±0.04^{d}**
Σn3/Σn6	**5.27**	**3.00**	**1.02**	**1.35**
DHA/EPA	**0.21**	**0.90**	**0**	**0.35**
AI	**1.15**	**1.40**	**1.31**	**0.87**
TI	**0.50**	**0.76**	**1.05**	**0.47**

x±stdev, n=3. Different superscript letters in the same row indicate significant differences (P < 0.05).

(C16:0). Oven baking, grilling or pan-frying considerably affected the fillets' polyunsaturated fatty acid content. Although some fatty acids were detected low in raw fillets, they were found at higher levels compared to the amount of fatty acids in raw material after heating treatments (C18:0, C18:1n9c, C18:2n6c, C18:3n3 and C22:6 n-3).

Pan-fried fish fillet showed significant changes in fatty acid profile as far as raw flathead grey mullets are concerned, possibly by reason of fat absorption during pan-frying. In conformance with Garcia-Arias et al. (2003), the changes were not homogenous for different fatty acids, while some fatty acids showed decreased activity, others showed increasing activity.

Choice of oil is very important, especially when frying low-fat fish, which can be expressed as the variability of the fatty acid composition of the oil that migrates to fish during frying. However, for fatty fish species such as King Salmon, this effect will be lower (Larsen et al. 2010). In the current study, using sunflower oil in frying negatively affects the omega-3 / omega-6 fatty acid ratio (C18: 2n6c) in pan-fried samples (Table 4). In particular, linoleic acid (C18: 2n6c) and similar omega-6 fatty acids found in sunflower oil have caused a change in the composition of fried products. And the rising values can be seen in Table 4. In a previous study, Gladyshev et al. (2006) studied the effect of cooking on PUFA in humpback salmon flesh. In their study, salmon fillets were fried, boiled, roasted and boiled (in small amounts of water). Gladyshev et al. (2006) found that heat activity did not decrease the EPA (Eicosapentaenoic Acid) or DHA (Docosahexaenoic acid) during boiling and roasting but in fried salmon samples, a moderate reduction was found. The hypothesis is that the absence of a reduction in PUFA level can be due to the higher levels of natural antioxidants which are contained in salmon fillets. But in the current study, when compared with the raw flesh, a significant decrease ($P<0.05$) in EPA content and a significant increase ($P<0.05$) in DHA content were determined (Table 4). This result can be explained by frying applied at lower temperature; since frying was applied at 185°C for 4 minutes for both sides. This duration and temperature is lower than other techniques used. Hypothesis to be developed from this result can be the reason for not using a long heating period and high temperature. In addition, the most interesting behaviour was observed in total PUFA ratio and EPA content of the grilled group. Loss in PUFA could be due to the loss of liquid content in grilling process as a result of drip loss. Over resistance of the oven, liquid contents were lost and dripping from the fillets were observed. Also, high temperature may have damaged the n-3 fatty acids. EPA, one of the most important fatty acids in fish lipids, was not found in grilled flathead grey mullets.

Although frying is the preferred cooking technique by some consumers, grilling and baking proved to be healthier alternatives. No significant difference was determined in the fatty acid compositions of raw and oven baked sample with respect to PUFA contents. Similar results were also obtained in the previous study of other researchers (Hosseini et al. 2014). In some studies no difference in the fatty acid profile among raw and baked fish species was reported (Turkkan et al. 2008; Hosseini et al. 2014).

Based on the atherogenicity and thrombogenicity equations proposed by Ulbricht and Southgate (1991), only SFA with chain lengths of 12 (lauric acid) to 16 (palmitic acid) are atherogenic, and myristic acid is considered to be four times more atherogenic than these two. All unsaturated fatty acids are thought to be equally effective in reducing atherogenicity regardless of the number of double bonds, position, or configuration. There is a lack of information in this regard in general terms. In the formulation direction there is a consequence change in the ratio of total omega-3 and omega-6 fatty acids (single and multiple bonds) with the ratio of specific SFA. For meat, the AI values are between 0.7 and 1.0, and the TI values range from 0.8 to 1.6 (Ulbricht and Southgate 1991). The atherogenic index of raw flathead grey mullets was found to be lower than in cooked samples except the pan-fried samples. Nevertheless, obtained values of oven baked flathead grey mullets were higher than those obtained from other fish such as; *Rutilus frisii kutum* (Hosseini et al. 2014) and African catfish (Rosa and Nunes 2007). Inverse correlation was obtained for thrombogenic index values of samples. Lower results than those reported for terrestrial animals were reported in different shrimp species (Rosa and Nunes 2007).

Sensorial results

The assessment of panel performance was used to analyse individual differences between assessors and to determine how cooking variations affect the product profile. For this aim grilled, oven-baked and pan fried fillets were compared by the panellists. Taken data are shown in Fig. 1.

According to the results of sensorial evaluation for each attribute scores were observed adequate in terms of odour (fresh odour, odour intensity, foreign odour), appearance (colour, flakiness), flavour (flavour intensity, fresh flavour, foreign flavour), and texture (firmness, chewiness, juiciness, fibrousness, fatness) parameters. An overall acceptability score of 1 was defined as the lower degree for acceptance and 5 was the highest degree for preferences. According to the results of general acceptability, the panellist found the products in the range of "liked". Sta-

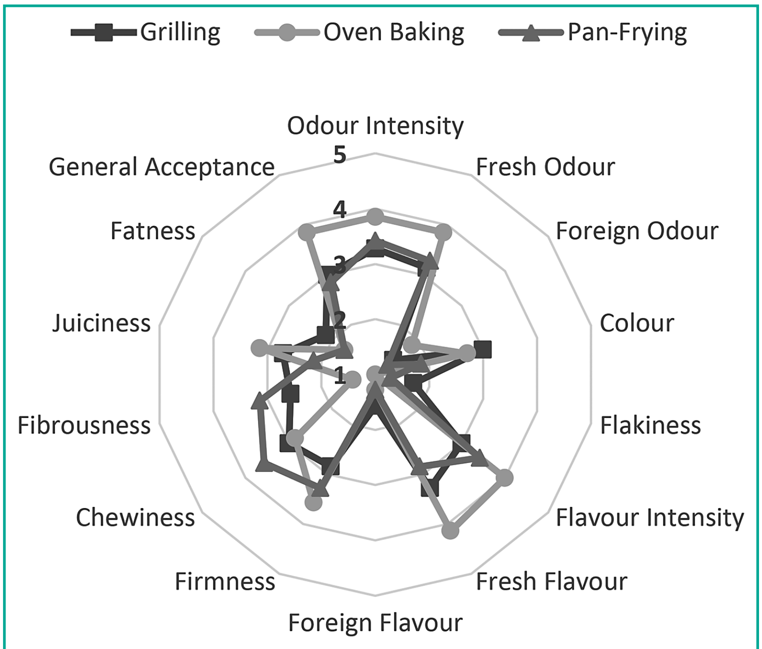

FIGURE 1: *Sensory analysis results of flathead grey mullet cooked by varied methods (grilling, oven baking, pan-frying). Sensory analysis scale used: 1-weak, 2- low, 3-adequate, 4-more, 5-intense.*

tistically no difference was determined in general acceptance criteria but oven-baked samples point (3.85±1.34) was found to be higher than grilled (3.0±1.15) and pan-fried (2.85±1.34) samples. Oven-baked flathead grey mullets achieved higher scores for odour intensity and fresh odour. However, Perez-Palacios et al. (2013) found that oven-baked samples were lower than pan-fried sampled. Grilled samples obtained high scores for colour and flakiness but had a lower level for flavour parameters. Uran and Gokoglu (2014) reported that baked anchovies were valued as lacking taste and flavour by panellists. However, this study presented that oven-baked flathead grey mullets showed high scores for flavour parameters.

Conclusion

All of the three cooking techniques affected the proximate composition, cooking loss, textural properties and fatty acids content of flathead grey mullet filets. The changes in the proximate composition were more effective in the pan-fried fillets. The fatty acid profile has been marginally affected by the grilling and pan-frying but has been greatly influenced by the pan-frying in the pan due to oil absorption. Moreover, as a conclusion oven-baked fillets appeared to be the best cooking methods concerning DHA/EPA and $\Sigma n3/\Sigma n6$ ratio in fatty acid composition.

Conflict of interest

The authors declare no conflict of interest.

References

Ameur WB, de Lapuente J, El Megdiche Y, Barhoumi B, Trabelsi S, Camps L, Serret J, Ramos-López D, Gonzalez-Linares J, Driss MR, Borras M (2012): Oxidative stress, genotoxicity and histopathology biomarker responses in mullet (Mugil cephalus) and sea bass (Dicentrarchus labrax) liver from Bizerte lagoon (Tunisia). Mar Pollut Bull 64(2): 241–251.

AOAC (1995): 16th Ed., AOAC International, Gaithersburg, MD, sec. 33.2.11, Method 991.20.

Bainy EM, Bertan LC, Corazza ML and Lenzi MK (2015): Effect of grilling and baking on physicochemical and textural properties of tilapia (Oreochromis niloticus) fish burger. J Food Sci Tech Mys 52(8): 5111–5119.

Bligh EG and Dyer WJ (1959): A Rapid Method of Total Lipid Extraction and Purification, Can J Biochem Phys 37(8): 911–917.

Carbonell I, Izquierdo L and Costell E (2002): Sensory Profiling of Cooked Gilthead Sea Bream (Sparus aurata): Sensory Evaluation Procedures and Panel Training. Food Sci Technol Int 8(3): 169–177.

Castro PL, Caballero MJ, Ginés R, Penedo JC, Montero D, Lastilla MT and Izquierdo M (2015): Linseed oil inclusion in sea bream diets: Effect on muscle quality and shelf life. Aquac Res 46(1): 75–85.

Dunajski E (1980) Texture of fish muscle. J Texture Stud 10(4): 301–318.

FAO (2018): Fisheries and Aquaculture Statistics 2016 FAO Yearbook. Rome, Italy, ISBN 978-92-5-130636-9.

Garcia-Arias MT, Pontes EA, Garcia-Linares MC, Garcia- Fernandez MC and Sanchez-Muniz FJ (2003): Cooking-freezing reheating (CFR) of sardine (Sardina pilchardus) fillets. Effect of different cooking and reheating procedures on the proximate and fatty acid compositions. Food Chem 83(3): 349–356.

Gladyshev MI, Sushnhik NN, Gubanenko GA, Demirchieva SM and Kalachova GS (2006): Effect of way of cooking on content of essential polyunsaturated fatty acids in muscle tissue of humpback salmon (Oncorhynchus gorbuscha). Food Chem 96(3): 446–451.

Hosseini H, Mahmoudzadeh M, Rezaei M, Mahmoudzadeh L, Khaksar R, Khosroshahi NK, Badakhani A (2014): Effect of different cooking methods on minerals, vitamins and nutritional quality indices of kutum roach (Rutilus frisii kutum). Food Chem 148: 86–91.

Ichihara K, Shibahara A, Yamamoto K and Nakayama T (1996): An improved method for rapid analysis of the fatty acids of glycerolipids. Lipids 31(5): 535–539.

Jafarpour A, Razmi M and Kavousi H (2015): Effects of Different Cooking Methods on Physical Properties and Sensory Evaluation of Rainbow Trout Fillets (Oncorhychus mykiss). Fisheries Science and Technology 4(1): 19–31.

Rowe C, Kerth CR (2013): Meat Cookery. In: Kerth CR (ed) The Science of Meat Quality. Wiley Publishing. 199-205. ISBN: 9780813815435.

Larsen D, Quek SY and Eyres L (2010): Effect of cooking method on the fatty acid profile of New Zealand King Salmon (Oncorhynchus tshawytscha). Food Chem 119(2): 785–790.

Lazo O, Guerrero L, Alexib N, Grigorakis K, Claret A, Pérez J and Bou R (2017): Sensory characterization, physico-chemical properties and somatic yields of five emerging fish species. Food Res Int 100(1): 396–406.

Ludorff W and Meyer V (1973): Fische und Fischerzeugnisse. 2nd ed. Berlin und Hamburg: Verlag Paul Parey.

Neff MR, Bhavsar SP, Braekevelt E, Arts MT (2014): Effects of different cooking methods on fatty acid profiles in four freshwater fishes from the Laurentian Great Lakes region. Food Chem 164, 544–550.

Nieva-Echevarría B, Goicoechea E, Manzanos MJ, Guillén MD (2018): Effects of different cooking methods on the lipids and volatile components of farmed and wild European sea bass (Dicentrarchus labrax). Food Res Int 103, 48–58.

Ozogul Y, Ozyurt G, Kuley Boga E (2009): Effects of cooking and reheating methods on the fatty acid profile of sea bream treated with rosemary extract. J Sci Food Agr 89(9), 1481–1489.

Palka K, Daun H (1999): Changes in texture, cooking losses, and myofibrillar structure of bovine M. semitendinosus during heating. Meat Sci 51(3): 237–243.

Perez-Palacios T, Casal S, Petisca C and Ferreira IMPLVO (2013): Nutritional and Sensory Characteristics of Bread-Coated Hake Fillets as Affected by Cooking Conditions. J Food Quality 36(6): 375–384.

Rosa R, Bandarra NM and Nunes ML (2007): Nutritional quality of African catfish Clarias gariepinus (Burchell 1822): A positive criterion for the future development of the European production of Siluroidei. Int J Food Sci Tech ogy 42(3): 342–351.

Schubring R (2002): Texture measurement on gutted cod during storage in ice using a hand-held instrument. Inf Fischwirtsch Fischereiforsch 49: 25–27.

Schubring R (2003): Colour measurement for the determination of the freshness of fish. In: Luten JB, Oehlenschlager J and Olafsdottir G (ed), Quality of Fish from Catch to Consumer: Labelling, Monitoring and Traceability. Wageningen Academic Publishers, Netherlands, 251–263.

Sengor GF, Özden Ö, Erkan N, Tüter M, Aksoy HA (2003): Fatty Acid Compositions of Flathead Grey Mullet (Mugil cephalus L., 1758) Fillet, Raw and Beeswaxed Caviar Oils. Turk J Fish Aquat Sc 3(2): 93–96

Sioen I, Haak L, Raes K, Hermans C, De Henauw S, De Smet S, Van Camp J (2006): Effects of pan-frying in margarine and olive oil on the fatty acid composition of cod and salmon. Food Chem 98(4), 609–617.

Stephen NM, Shakila RJ, Jeyasekaran G and Sukumar D (2010): Effect of different types of heat processing on chemical changes in tuna. J Food Sci Tech Mys 47(2): 174–181.

Stonehouse W (2014): Does Consumption of LC Omega-3 PUFA Enhance Cognitive Performance in Healthy School-Aged Children and throughout Adulthood? Evidence from Clinical Trials. Nutrients 6(7): 2730–2758.

Turkkan AU, Cakli S, Kilinc B (2008): Effects of cooking methods on the proximate composition and fatty acid composition of seabass (Dicentrarchus labrax, Linnaeus, 1758). Food Bioprod Process 8(6): 163–166.

Ulbricht TL, Southgate DAT (1991): Coronary heart disease: seven dietary factors. Lancet 338: 985–992.

Uran H, Gokoglu N (2014): Effects of cooking methods and temperatures on nutritional and quality characteristics of anchovy (Engraulis encrasicholus). J Food Sci Tech Mys 51(4): 722–728.

Zheng J, Huang T, Yu Y, Hu X, Yang B, Li D (2012): Fish consumption and CHD mortality: An updated meta-analysis of seventeen cohort studies. Public Health Nutr 15(4), 725–737.

Zhang J, Wu D, Liu D, Fang Z, Chen J, Hu Y, Ye X (2013): Effect of cooking styles on the lipid oxidation and fatty acid composition of grass carp (Ctenopharynyodon idellus) fillet. J Food Biochem 37(2): 212–219.

Address of corresponding author:
Dr. Ömer Alper Erdem
Ege University, Faculty of Fisheries
Department of Fish Capturing and Fish Processing Technology, Section of Fish Processing Technology
35100 Bornova, Izmir
Turkey
omer.alper.erdem@ege.edu.tr

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

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

Lebensmittel im Blickpunkt: Fruchtsäfte nur sehr selten belastet

Ob Apfel, Orange oder Kirsch: Rückstände von Pflanzenschutzmitteln oder Schwermetalle werden kaum gefunden

Fruchtsäfte sind aufgrund ihres Vitamingehalts als Durstlöscher beliebt und werden auch von Kindern häufig getrunken. Wie die regelmäßigen Untersuchungen der Lebensmittelüberwachungsämter der Bundesländer zeigen, sind Fruchtsäfte und auch Fruchtnektare erfreulicherweise nur sehr selten belastet. Überhöhte Rückstände von Pflanzenschutzmitteln oder hohe Konzentrationen von Schwermetallen wurden nur in Einzelfällen gefunden, wie das Bundesamt für Verbraucherschutz und Lebensmittelsicherheit (BVL) in Berlin mitteilt.

2017 haben die Untersuchungslabore der Bundesländer insgesamt 114 Proben Apfel-, Birnen-, Grapefruit-, Kirsch-, Orangen-, Trauben- und Zitronensaft auf Rückstände von Pflanzenschutzmitteln hin untersucht. In keinem Fall mussten sie eine Überschreitung der gesetzlichen Höchstgehalte feststellen. In 77 Proben (rund 68 %) wurden gar keine quantifizierbaren Rückstände nachgewiesen. 2016 wurden insgesamt 169 Proben Apfelsaft auf Rückstände von Pflanzenschutzmitteln untersucht. Dabei wurden in keiner Probe Rückstände oberhalb des festgesetzten Höchstgehalts nachgewiesen. Rund 65 % der Proben wiesen überhaupt keine Rückstände auf. Die Bundesländer untersuchen regelmäßig die verschiedensten Lebensmittel auf Pflanzenschutzmittelrückstände. Die Ergebnisse werden jährlich vom BVL als Nationale Berichterstattung Pflanzenschutzmittelrückstände in Lebensmitteln veröffentlicht.

Außerdem untersuchen die Lebensmittelüberwachungsämter jedes Jahr wechselnde Lebensmittel im Rahmen des Lebensmittel-Monitorings repräsentativ auf Belastungen. So wurden im Jahr 2017 111 Proben Kirschsaft und -nektar untersucht. Auch hier wurden in keiner Probe Rückstandshöchstgehalte überschritten. Rückstände wiesen dabei etwas mehr als die Hälfte der Proben auf.

Kein Nachweis von Perchlorat

Im Monitoring 2015 und 2017 wurden 47 Proben Orangensaft, 37 Proben Traubensaft und 20 Proben Kirschsaft auf Perchlorat untersucht. Die Umweltkontaminante gelangt hauptsächlich über die Verwendung von perchlorat-haltigen Düngemitteln, wie Chilesalpeter, in pflanzliche Lebensmittel. Die Aufnahme von Perchlorat kann die Jodidaufnahme in der Schilddrüse hemmen. Erfreulicherweise konnten die Labore in keiner Probe Perchlorat nachweisen. Das zeigt, dass durch Minimierungsmaßnahmen (etwa der Verwendung von Düngemitteln mit sehr niedrigem Perchlorat-Gehalt) eine Kontamination weitgehend vermieden werden kann.

Seit Jahren geringe Gehalte an Elementen

Auch das Vorkommen von Elementen wie Schwermetalle und Aluminium wurde im Rahmen des Lebensmittel-Monitorings untersucht. Elemente können aus dem Boden, dem Wasser oder der Luft stammen, aber auch durch industrielle Prozesse in die Nahrungskette eingetragen werden. In den Jahren 2009 bis 2017 wurden Apfelsaft (108 Proben), Organgensaft (77 Proben), Traubensaft (151 Proben), Kirschsaft bzw. -nektar (217 Proben) und Birnensaft (116 Proben) untersucht. Dabei wurden die Gehalte von Blei, Cadmium, Nickel, Arsen und Aluminium überprüft, bei Apfel- und Kirschsaft zusätzlich auch von Thallium.

Die Ergebnisse zeigten, dass Fruchtsäfte nur sehr gering mit Cadmium, Arsen und Thallium belastet waren. Die durchschnittlichen Gehalte lagen im niedrigen Spurenbereich von 0,001 mg/kg bis etwa 0,01 mg/kg. Die Gehalte an Aluminium und Nickel waren als gering einzustufen. Cadmium und Thallium waren im weit überwiegenden Anteil der Fruchtsaftproben nicht nachweisbar.

Für Blei in Fruchtsäften sind in der EU Höchstgehalte festgeschrieben. Für Fruchtsäfte, die ausschließlich von Beeren und anderem Kleinobst wie Kirschen und Trauben gewonnen werden, gilt ein Höchstgehalt von 0,05 mg/kg. Für alle anderen Säfte liegt der Höchstgehalt bei 0,03 mg/kg. Höchstgehaltsüberschreitungen für Blei mussten im Monitoring nur in einer Probe Apfelsaft sowie in zwei Proben Kirschsaft festgestellt werden. Im Bundesweiten Überwachungsplan (BÜp) 2017 wurden ebenfalls verschiedene Fruchtsäfte und -nektare auf ihren Blei-Gehalt untersucht. Von den insgesamt 500 untersuchten Proben wies nur eine Probe Birnensaft einen Blei-Gehalt oberhalb des Höchstgehaltes auf.

Aufgrund seiner toxischen Wirkungen kann bei Blei, so die Europäische Lebensmittel-sicherheitsbehörde EFSA, jedoch keine Aufnahmemenge abgeleitet werden, die als gesundheitlich unbedenklich gilt. Die Blei-Gehalte in Lebensmitteln sind daher auf so niedrige Werte zu begrenzen, wie dies für den Hersteller oder Verarbeiter vernünftigerweise bzw. technologisch möglich ist. Vor diesem Hintergrund begrüßt das BVL die aktuellen geringen Blei-Gehalte in Fruchtsaft bzw. -nektar. Besonders erfreulich ist daher auch die rückläufige Entwicklung bei Kirschsaft, der sowohl 2011 als auch 2017 im Monitoring auf Blei untersucht wurde. Der durchschnittliche Blei-Gehalt ging von 0,01 mg/kg auf 0,007 mg/kg zurück und der maximale Blei-Gehalt von 0,06 mg/kg auf 0,02 mg/kg.

Weitere Informationen (Quelle):
Bundesamt für Verbraucherschutz und Lebensmittelsicherheit (BVL) | **www.bvl.bund.de**