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Comparing the Fatty Acid Level of Sand Smelt (*Atherina boyeri*) With Rainbow Trout (*Oncorhynchus mykiss*) as a Cheaper Protein and Fatty Acid Source

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Research Article

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Abstract

Sensorial and fatty acid levels of sand smelt as an alternative protein and fatty acid source against rainbow trout were investigated. The fish were separated into two groups; which were identified in expensive/known one (rainbow trout) and the cheaper/little-known one (sand smelt). Although rainbow trout and sand smelt groups have the same proximate and sensorial values, sand smelt group preferred more according to price/flavor preference. The fatty acid combinations of groups changed from 27.56% to 38.80% saturated (SFA), 26.30–31.22% monounsaturated (MUFAs) and 34.91–41.22% polyunsaturated acids (PUFAs). Between the groups, the highest rates were myristic acid (3.15–3.73%), palmitic acid (15.99–26.85%), palmitoleic acid (5.82–6.01%), stearic acid (4.44–6.40%), oleic acid (11.81–20.40%), linoleic acid (2.47–16.73%), eicosapentaenoic acid (2.30–8.80%) and docosahexaenoic acid (7.84–15.77%). The values of PUFAs-n3 and DHA were higher in a cheaper group than an expensive one.

Keywords: Alternative protein source, DHA, EPA, san smelt, rainbow trout

Daha Ucuz Bir Protein ve Yağ Asidi Kaynağı Olarak Gümüş Balığı (*Atherina boyeri*) ile Gökkuşağı Alabalığının (*Oncorhynchus mykiss*) Karşılaştırılması

Özet

Alternatif bir protein ve yağ asidi kaynağı olarak gümüş balığının gökkuşağı alabalığına karşı yağ asidi seviyeleri araştırılmıştır. Balıklar iki gruba ayrılarak; pahalı / bilinen (gökkuşağı alabalığı) ve daha ucuz / az bilinen (gümüş balığı) olarak tanımlandı. Gökkuşağı alabalığı ve gümüş balığı grupları yakın besin ve duyusal değerlere sahip olsa da gümüş balığı grubu fiyat / lezzet tercihine göre daha fazla tercih edilmiştir. Grupların yağ asidi kombinasyonları 27,56%'dan 38,80% doymuş (SFA), 26,30%–31,22% tekli doymamış (MUFA) ve 34,91%-41,22% doymamış asitleri (PUFA) şeklinde değişmiştir. Gruplar arasında en yüksek oranlar miristik asit (3,15-3,73%), palmitik asit (15,99-26,85%), palmitoleik asit (5,82-6,01%), stearik asit (4,44-6,40%), oleik asit (11,81-20,40%), linoleik asit (2,47-16,73%), eikosapentaenoik asit (2,30-8,80%) ve dokosaheksaenoik asit (7,84-15,77%) idi. PUFAs-n3 ve DHA değerleri daha ucuz olan grupta pahalı gruba göre daha yüksekti.

Anahtar Kelimeler: Alternatif protein kaynağı, DHA, EPA, gümüş balığı, gökkuşağı alabalığı

INTRODUCTION

Aquatic products include important polyunsaturated fatty acids for human health such as EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) and also a high level of protein and minerals (Ackman, 1999). These long chain polyunsaturated fatty acids have great importance to humans for the prevention of coronary artery disease, brain health, inflammatory and cancer (Simopoulos, 1991; Conner, 2000; Ward and Singh, 2005; Giudetti and Cagnazzo, 2012; La Rovere and Christensen, 2015). Although DHA is the main part of heart muscles, brain and eye retina (Ward and Singh, 2005), EPA is also important for brain disorders and cancer treatment (Fenton et al., 2000).

Depending on population growth, there is a trend towards alternative protein sources in the world. Tasting and traditional culture are the most important factor in receiving the protein requirements. But usually, it can be difficult to find a healthy and tasty combination of foods. Fish are the major participator of PUFA for the human diet but different fish species have variable fatty acid compositions. Fatty acid composition of fish species can be variable depending on factors such as gender, location and environmental conditions (Özoğul et al., 2007). Therefore, different fish species should be preferred in diets. But for consumers, it is important that the product must have economical and tasty specialties.

In today's society, many fish consumers consume culture fish such as trout, sea bream, and sea bass. A lot of studies have been made on the nutritional profiles of them (Tidball et al., 2017; Turchini et al., 2018; Iaconisi et al., 2018). But some species like sand smelt (*Atherina boyeri*) are not well known by consumers due to not being sold by fish markets. Another reason is that these fish are too small and people do not know that they can eatable. And sometimes frying of ungutted sand smelt with head may be strange for people. But only little groups of consumers who know this fish from their ancestors are consuming this fish with pleasure. 4630 tons of sand smelt were hunted in Turkey in 2018 (TUIK) and a large part is exported at a price as low as 50 cents. On the other hand, countries that import sand smelt from our country sell it to the level of 9 Euros under the name "finger fish". At the same time in recent years, researchers published some processing methods of making fish chips and other processing methods of sand smelt (Kalogeropoulos et al., 2004; İzci et al., 2011). But despite this, the price is still very affordable.

Although there are lots of studies that have pointed with fatty acid profiles of some fish species there is a little information on the fatty acid profile of sand smelt. The aim of this study was to determine the fatty acid (FA), proximate profiles and sensorial opinions of sand smelt as a cheap source and compare the values with popular market fish known as rainbow trout.

MATERIALS and METHODS

Fish Samples

Sand smelt (*Atherina boyeri*) was purchased by local hunters in Kırşehir, Hirfanlı Dam, Turkey and rainbow trout (*Oncorhynchus mykiss*) was taken from a cage fish producer (LBG Trout Farm) located on Hirfanlı Dam (Kırşehir Turkey) in November 2017. The average weight of trout was 260 ± 10,2 g and length of both samples were 22 ± 3 cm. The length of sand smelt were between 11-18 cm and weight were between 1-3 g. Rainbow trout were killed by hitting to head (anterior of the brain) which is fast and humane. Harvested trout and hunted sand smelt were delivered to the laboratory in polystyrene boxes with ice within 1 h of harvesting. 10 trout and 30 sand smelt were used for fatty acid analysis and also 30 trout and 250 sand smelt were used for sensory analysis.

Proximate Composition

Kjeldahl technique (AOAC, 1990) was used for the crude protein and Bligh and Dyer (1959)'s method was used for lipid analyses. Also moisture and ash content was analyzed with the method of AOAC (1984).

Fatty Acid Analysis

Fatty acid composition was determined according to Ichihara and others (1996). 4 ml of 2M KOH and 2 ml of n-heptane were added to 25 mg of extracted oil sample. It was then vortexed for 2 minutes at room temperature and centrifuged at 4000 rpm for 10 minutes and the heptane layer was taken for GC analysis. Determination of fatty acids was accomplished using a Perkin Elmer GC (Clarus 500) with an autosampler (Perkin Elmer, Shelton, CT, USA), equipped with a flame ionisation detector and a fused silica capillary column (30 m × 0.32 mm i.d., 0.25 µm; SGE Analytical Science Pty Ltd, Melbourne, Australia). The oven temperature was 140 °C, held for 5 min, increased to 200 °C at a rate of 4 °C/min, and increased to 220 °C at a rate of 1 °C/min, while the injector and the detector temperature were set at 220 and 280 °C, respectively. The carrier gas was controlled at 16 ps. The split used was 1 : 100. Fatty acids were identified by comparing the retention times of fatty acid methyl esters (FAMEs) with the Standard 37-component FAME mixture obtained from Sigma-Aldrich Chemie Gmbh, Munich, Germany. Two replicate samples were run and data was indicated as the percentage of the mean value.

Sensory Analysis

Cooked fish analyses were made by Paulus et al. (1979) with some modifications. The opinions of the panelist for color, odour, flavor, texture and general acceptability scored to the given pages using

9-point hedonic scale (1 excessively dislike, 9 excessively like). For the analysis of cooked fish, trout group was filleted and samples were cooked for 5 minutes at sunflower oil. But sand smelt did not fillet and cooked ungutted with head in sunflower oil. Because sand smelt should be cooked in oil, rainbow trout was also cooked in oil. So that the overall cooking and eating perception was also measured. In addition to standard questions, the panelists were asked which fish they would prefer in terms of price/flavor. For price/flavor preference sand smelt cost given as 50 Cent/kg and trout cost given as 5 Dollars/kg. Analyses were done on each test day in natural day conditions by the staff members and 4th semester students of the Ahi Evran University Food Processing Department who are familiar with fresh fish and fish products also the panelists were selected from those who had never eaten sand smelt before.

Statistical analysis

SPSS 22 version software (Chicago, Illinois, USA) used for one-way variance analysis (ANOVA) and Duncan's Multiple Range Test. Calculations were done in triplicate and comparisons at p value of <0.05 were carried out to point out significant differences.

RESULTS and DISCUSSION

Protein, lipid, moisture and crude ash contents of sand smelt and rainbow trout are given in Table1.

Table 1. Proximate composition of rainbow trout and sand smelt

Proximate composition (%)	Rainbow trout	Sand smelt
Protein	17.11±1.22^{x}	16.82±1.12^{x}
Lipid	5.09 ±0.22^{x}	3.58±0.37^{y}
Moisture	76.22±1.27^{x}	76.27±0.95^{x}
Crude ash	1.58±0.03^{x}	3.33±0.02^{y}

Different letters (x − y) in the same fraction show significant differences (p < 0.05).

Sensory analyse results of trout and sand smelt are given in Table2. The table shows color, smell, flavor and tissue structure as standard quality questions. In addition to these parameters, the price-flavor option was added to the table.

Table 2. Sensory analysis of cooked rainbow trout and sand smelt

Analyses	Rainbow trout	Sand smelt
Color	8.3±0.82^{a}	8.7±0.48^{a}
Smell	8.4±0.51^{a}	8.1±0.56^{a}
Flavor	8.4±0.69^{a}	8.7±0.48^{a}
Tissue structure	9.0±0.00^{a}	9.0±0.00^{a}
Price/Flavor preference*	5.9±0.73^{b}	8.2±0.63^{a}

*Price/ Flavor preference: Sand smelt cost given as 50 Cent/kg and trout cost given as 5 Dollars/kg. Different letters (a − b) in the same fraction shows significant differences (p < 0.05).

There were no significant differences (p>0.05) between groups according to the values of protein and moisture (Table1). However, Tokur et al. (2006) reported a higher protein level (22.96%) and lower lipid content (2.71%) for cultured rainbow trout compared to the current study. But İzci et al., (2011) reported similar protein and lipid contents for sand smelt. Lipid content of trout and sand smelt were exhaust to the components of the diet of the fish so lipid content was higher (5.09 ± 0.22%) in rainbow trout than sand smelt (3.02 ± 0.22%). Some factors such as geographic location, season and size or age effect fat content and composition of fish muscle (Ackman, 1989). In this study, it is important that two species have the same protein levels. This means that cheaper one may become an important protein source provided that it is delicious.

Table 2 shows the sensory analyses of trout and sand smelt. The fresh flavor characteristics of the species were strong in all groups. Off-flavours and off-odours were not detected and there was not any rejection point for the cooked sand smelt bodily. Although they were prejudiced about eating sand smelt bodily with head all the panelists liked this style. There were no significant differences between trout and sand smelt according to color, smell, flavor and tissue structure while significant difference was observed in price/flavor preference ($p < 0.05$). Sand smelt cost is given as 50 Cent/kg and trout cost given as 5 Dollars/kg to the panelist according to the market data. The panelists who were selected from those who had never eaten sand smelt before but eaten trout before liked sand smelt very much and they described boned and bodily sand smelt like chips.

Table3. Fatty acid content of rainbow trout and sand smelt (%)

FA	Rainbow trout	Sand smelt
C12:0	$0.02{\pm}0.14^{b}$	$0.56{\pm}05^{a}$
C14:0	$3.15{\pm}0.9^{a}$	$3.73{\pm}0.1^{a}$
C15:0	$0.03{\pm}0.01^{b}$	$0.63{\pm}0.07^{a}$
C16:0	$15.99{\pm}0.26^{b}$	$26.85{\pm}1.48^{a}$
C17:0	$0.80{\pm}0.14^{a}$	$0.63{\pm}0.02^{a}$
C18:0	$4.44{\pm}0.35^{b}$	$6.40{\pm}0.39^{a}$
C20:0	$1.47{\pm}0.12^{a}$	$0{\pm}0.00^{b}$
C21:0	$1.55{\pm}0.48^{a}$	$0{\pm}0.00^{b}$
C22:0	$0.11{\pm}0.02^{a}$	$0{\pm}0.00^{b}$
∑ **SFA***	27.56	38.795
C14:1n5	$0.06{\pm}0.01^{b}$	$1.22{\pm}0.04^{a}$
C16:1n7	$5.82{\pm}0.37^{a}$	$6.01{\pm}0.17^{a}$
C17:1n8	$1.33{\pm}0.27^{a}$	$0.40{\pm}0.03^{b}$
C18:1n9	$20.40{\pm}1.35^{a}$	$11.81{\pm}0.97^{b}$
C18:1n7	$0.03{\pm}0.02^{b}$	$5.61{\pm}0.26^{a}$
C20:1n9	$2.94{\pm}0.45^{a}$	$1.27{\pm}0.16^{b}$
C22:1n9	$0.66{\pm}0.19^{a}$	$0{\pm}0.00^{b}$
∑ **MUFA****	31.22	26.30
C18:2 n6	$16.73{\pm}1.42^{a}$	$2.47{\pm}0.49^{b}$
C18:3 n6	$0.10{\pm}0.01^{b}$	$1.50{\pm}0.12^{a}$
C18:3 n3	$5.18{\pm}0.53^{a}$	$0.43{\pm}0.01^{b}$
C20:2 n6	$0.32{\pm}0.02^{b}$	$0.65{\pm}0.04^{a}$
C20:3n6	$0.05{\pm}0.01^{a}$	$0{\pm}0.00^{b}$
C20:3n3	$0.02{\pm}0.01^{b}$	$1.25{\pm}0.09^{a}$
C20:4n6	$1.03{\pm}0.21^{b}$	$3.17{\pm}0.44^{a}$
C20:5 n3	$2.30{\pm}0.11^{b}$	$8.80{\pm}0.31^{a}$
C22:2n6	$0.20{\pm}0.02^{b}$	$0.60{\pm}0.02^{a}$
C22:5 n3	$7.47{\pm}0.96^{a}$	$0.28{\pm}0.09^{b}$
C22:6 n3	$7.84{\pm}0.68^{b}$	$15.77{\pm}0.35^{a}$
∑ **PUFA*****	41.22	34.91
PUFA/SFA	1.50	0.90
DHA/EPA	3.41	1.79
∑ **ω3**	22.80	26.53
∑ **ω6**	18.42	8.38
∑ **ω6 / ∑ ω3**	0.81	0.32

*SFA: Saturated fatty acid, **MUFA: Monounsaturated fatty acid, ***PUFA: Polyunsaturated fatty acid. Different letters (a − b) in the same fraction shows significant differences ($p < 0.05$).

It is known that the lipid content of fish can be variable depending on factors such as species and diet, (Rasoarahona et al., 2005). Table 3 shows the % as a mean value of 27 fatty acids for two groups. The fatty acid compositions of groups ranged from 27.56% to 38.80% SFA, 26.30–31.22% MUFAs and 34.91–41.22% PUFAs. Between them, those occurring in the highest rates were myristic acid (3.15–3.73%), palmitic acid (15.99–26.85%), palmitoleic acid (5.82–6.01%), stearic acid (4.44–6.40%), oleic acid (11.81–20.40%), linoleic acid (2.47–16.73%), eicosapentaenoic acid (2.30–8.80%) and docosahexaenoic acid (7.84–15.77%). The results showed that sand smelt is very rich in n-3 polyunsaturated fatty acids (%34. 91) like trout (%41. 22). Similar results were reported for rainbow trout and sand smelt (İzci et al., 2011). The levels of SFA between rainbow trout and sand smelt was varied but it can be variable too for the same species as reported (Haliloğlu et al., 2001). PUFA/SFA value found as 1.50 in trout and 0.90 in sand smelt. So these values are higher than the minimum value of PUFA/SFA recommended as 0.45 (HMSO, 1994). Palmitic acid was the primary saturated fatty acid contributing 15.99% and 26.85% of the total saturated fatty acid content of lipids for rainbow trout and sand smelt respectively. Oleic acid was the primary MUFAs accounting for 20.40% of total MUFAs for rainbow trout while it contributes 11.81% of total MUFAs for sand smelt. And similarly linoleic acid was the primary PUFAs for rainbow trout contributing 16.73% while sand smelt was 2.47%.

Among the analyzed fish species, the highest EPA and DHA were obtained from sand smelt, accounting for 8.80% and 15.77% of total PUFAs respectly while rainbow trout group was 2.30% EPA and 7.84% DHA. It is known that EPA and DHA values can be higher hunted fish species compared to cultured fish species (Chen et al., 1995; Rahman et al., 1995). EPA is the most important essential fatty acid among the n3 series fatty acids for the human diet (Chen et al., 1995) and also DHA decreases the concentration of low density lipoprotein cholesterol in plasma (Childs et al., 1990). Differences in fatty acids of rainbow trout and sand smelt should not only be considered with respect to species habitat but also based on their natural diet.

Shang et al., 2017 reported that the ratio of 1:2 DHA/EPA decreased the level of serum triglycerides and total cholesterol on mice. There was no group in which the DHA / EPA ratio approached 1/2 in this study but the limit of these ratios has not yet been stabled in the literature.

Among the groups, the highest ratio of n6/n3 was found to be 0.81 for rainbow trout followed by 0.32 for sand smelt. The ratios of n6/n3 found in this study were lower in both rainbow trout and sand smelt than the value (4.0 at maximum) recommended by the UK Department of Health (HMSO, 1994). Simopoulos (2010) reported that a ratio of 1:1 to 2:1 ω6/ω3 fatty acids should be the ideal for human health.

CONCLUSION

This work is important because it can be a source of inspiration to people who helps food aid to poor countries. Also, sand smelt is found in abundance in our and other countries but its price is 50 cents because it is a little known species. However, in Europe fish chips have been made with these fish and sold at a price of 20 Euros. Therefore, the high level of omega-3 and omega-6 of sand smelt shared in this study may cause new initiatives. Although there is an important difference in the market about prices of rainbow trout and sand smelt species, this study exhibits that fatty acid, proximate and sensorial profiles of sand smelt are comparable to those of trout as sources of PUFAs and MUFAs. Besides this, despite their first-time consumption, the panelists were overjoyed at the taste of sand smelt. Nowadays the economic level of every consumer is variable and generally healthy foods such as fish can be expensive. This study will contribute to the identification of nutritional compositions of an alternative and less known functional food type and to the maintenance of community health.

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