CHEMICAL AND FATTY ACID COMPOSITION OF TURBOT (*PSETTA MAXIMA MAEOTICA*) MEAT FROM THE BULGARIAN BLACK SEA SHORES

LILIANA HADZHINIKOLOVA, ANGELINA IVANOVA, TANIA HUBENOVA
Institute of Fisheries and Aquaculture, 248 V. Levski str., 4003 Plovdiv, Bulgaria
E-mail: hadjinikolova@abv.bg

HEMIJSKI I MASNO KISELINSKI SASTAV MESA IVERKA (*PSETTA MAXIMA MAEOTICA*) IZ BUGARSKOG DELA CRNOG MORA

Apstrakt

Cilja rada je bio da se analizira hemijski i masno kiselinski sastav mesa ivera (Psetta maxima maeotica) ulovljenog u Bugarskom delu Crnog mora. Iver je lovljen kočarenjem u periodu od 12 do 30 novembra 2014 sa 5 proizvoljno određenih zona od ukupno 38 zona. Ovo istraživanje je pokazalo da postoje izražene razlike u hemijskom sastavu i energetskoj vrednosti mesa ivera uhvaćenog sa različitih lokaliteta u severnom i južnom sektoru Crnog mora. Konstatovana su veća variranje u proteinskom sastavu od 16.87 % (južni sektor) do 19.32 % (severni sektor) u odnosu na variranje nivoa masti u mesu (1.29 - 2.08 %). *Na osnovu nivoa masti, ribe sa istraživanih područja bi mogle da se klasifikuju kao posna (niskomasna) grupa riba.*

Na osnovu prisustva specifičnih masnih kiselina u mesu ivera iz zona C17-E9 i E11-E13 i dubine kočarenja od 36-53 m, ove ribe se mogu svrstati u palmitinski tip, dok se ribe ulovljene iz zona L1-7/M2/N1-2 i dubine od 52-64 m mogu svrstati u oleinsko-palmitinski tip. Biološki važan odnos n-3 i n-6 masnih kiselina je varirao u opsegu od 0.06 do 0.13 što je zadovoljavajući nivo propisan od strane WHO (Svetske zdravstvene organizacije) koji smanjuje rizik po ljudsko zdravlje (<5.0). Odnos PUFA/SFA u lipidima ivera je varirao od 0.36 do 0.54, sa boljim balansom masnih kiselina u mesu riba iz severnog sektora Crnog mora (0.54).

Ključne reči: iver, masne kiseline, odnos masnih kiselina, lipidne grupe
Keywords: turbot, fatty acids, fatty acid ratios, lipids groups

INTRODUCTION

The turbot (*Psetta maxima maeotica*) is one of commercial fish species in the Black Sea. The Black Sea turbot is a demersial fish, spawning in the spring, during autumn it approaches the shores at a depth of 10-30 m for fattening, whereas winter gatherings are at a depth of 70-90 m. It prefers sandy mussel beds. The adult turbot is a predator, and feeds mainly on demersial fish, gobies, whitings etc., crustaceans and molluscs. Turbot meat is white, tender and with excellent flavour, that is why it is a valuable and much sought fish. Deep-sea fish including Black Sea turbots are not only a dietary source of biologically valuable proteins, but also a food with healthy components (Suseno et al., 2010), as vitamins, essential fatty acids, macro- and trace minerals (Özyrut et al., 2009). In natural basins, the nutritional value of fish is mainly modulated by the available natural food. According to Steffens (2006), the lipid content of naturally inhabiting species could not be altered and is highly dependent on the species and amount of available food.

During recent years, studies on the seasonal patterns of total fat content and fatty acids of Black Sea turbots have been carried out (Merdzhanova, 2014). Systemic observations on the age, season, environmental conditions etc. that are acknowledged to influence the meat biochemical composition, are scarce on a national scale.

The investigation of changes in the plastic metabolism, quantity and quality of fatty acids and tocopherols with regard to the autumn catch places at the Bulgarian Black Sea shores allows for objective information and evaluation of the nutritional value of Black Sea turbots, hence contribution to the study of the species' biology.

Therefore, the aim of the present study was to analyse the chemical and energy content of meat, as well as fatty acid composition of meat lipids in turbots (*Psetta maxima maeotica*) caught at the Bulgarian Black Sea shore.

MATERIAL AND METHODS

In this study, turbots (*Psetta maxima maeotica*) caught at the Black Sea by trawling of 5 areas, randomly selected from the total number of 38 areas between 12 and 30 November 2014 were used (Table 1). The standard methodology for stratified sampling from the seasonal aquatory of fish, the swept area method, was applied (Sparre and Venema, 1998; Sabatella and Franquesa, 2004). Trawlings were performed by means of bottom trawl, 10×10 cm mesh size, holding the net for 60 min at towing speed of 1.2 knots. Turbots were divided into 5 groups according to catch area and depth. Fish with size average for the group were selected, ranging from 800 to 1600 g from strata 2 and 3.

Table 1. Place and date of turbot catch

Black Sea	Southern sector		Northern sector		
Date	19-28.11.2014	17.11.2014	12.11.2014	12.11.2014	12.11.2014
Place of catch	C17-E9	E11-E13	L1-7	M-2	N1-2
Depth, m	36-41	53	52	61	64

For meat chemical analysis, fillet samples were obtained from the same body part. The following parameters were determined: water content % (drying at 105 ^{o}C, 24 h), protein content % (Kjeldahl method, semi-automated DK 6 digester unit and UDK 132 distillation system, Velp Scientifica;), fat content % (by the method of Smidt-Boudzynski Ratzlaff); mineral content % (by burning in a muffle furnace at 550 ^{o}C). The energy content of turbot meat was calculated on the basis of the chemical composition using the following coefficients: 17 kJ.g^{-1} for proteins and carbohydrates and 37.0 kJ.g^{-1} for fat (Ordinance 23/2001, Ministry of Health).

The fatty acid composition of meat triglycerides was analysed by gas chromatography using a HP 5890 II gas chromatograph with flame ionisation detector, 60 m DB-23 capillary column, column temperature – 130 ^{o}C (1 min), 6.5 ^{o}C/min increments up to 170 ^{o}C, 3.0 ^{o}C/min increments up to 215 ^{o}C (12 min); 40.0 ^{o}C/min up to 230 ^{o}C (1 min); detector temperature – 280 ^{o}C; injector temperature – 270 ^{o}C, carrier gas – hydrogen (H_2), split 1:50 and software Data Apex Clarity^{TM} 2.4.1.93/2005. The individual fatty acid content was identified with standards and through retention times. Fatty acid groups, fatty acid ratios, as well as group ratios were calculated.

RESULTS AND DISCUSSION

Chemical composition and energy content of turbot meat

Water, protein, fat and mineral content of meat of studied groups of turbot is presented in Table 2. Water content varied within 78.23 % - 79.26% (northern sector) to 80.03 - 80.37 % (southern sector). The difference between values was < 3%. Data demonstrated that water was the main chemical constituent of studied turbot groups. This parameter is important for organoleptic properties of meat.

Table 2. Chemical composition (% of wet matter) and energy value (kJ.100 g^{-1}) of meat

Place of catch	C17-E9	E11-E13	M2	N1-2	L1-7
Water	80.37	80.03	78.30	79.26	78.56
Proteins	19.87	16.99	19.32	18.56	18.88
Fats	1.76	2.08	1.52	1.29	1.69
Ash	1.00	0.90	0.86	0.89	0.84
Energy (total), kJ.100 g^{-1}	351.91	365.79	384.68	363.25	383.49

Absolute values of protein content were from 16.87 % (C17-E9) to 19.32 % (M2). The studied groups of fish were distinguished with high relative proportion of protein on the dry matter basis from 85.08 - 85.94% (southern Black Sea sector) to 88.2-89.49 % (northern Black Sea sector). The high protein content of turbot meat predetermines its good nutritional quality.

Turbot meat fat values varied from 1.29 % to 2.08 % depending on sea sector, whereas the relative fat content on DM basis was 6.22 - 10.42 %. Detected values were lower than total fat content of turbot from the autumn catch (October-November) reported by Merdzhanova (2014). On the basis of the classification of Kyosev and Dragoev (2009), the turbot groups from studied fields were referred to the lean fish group (with meat fat content < 2%). The low fat content indicated that by the end of November, meat of turbots still gathered energy nutrients in relation to the fattening habitat and local trophic level. Mineral content of turbot meat varied from 0.84 to 1.00 %. Energy value of meat in studied fields ranged between 351.91 kJ.100 g^{-1} and 384.68 kJ.100 g^{-1}.

Quantity and quality of fatty acids in turbot meat lipids

The main groups of fatty acids in turbot meat lipids are shown in Table 3.

Turbot meat lipids contained all three groups of fatty acids – saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) distributed as followed: MUFA > SFA > PUFA.

SFA content varied within a narrow range: 38.1-41.9 %. The values were comparable to those established by Merdzhanova (2014) in her study on the fatty acid composition of Black Sea turbots caught during the autumn. The saturated fatty acids in studied samples were mainly represented by the palmitic (C16:0) and myristic (C14:0) acids, followed by stearic acid (C18:0), in the following order: C16:0 > C14:0 > C18:0. The group of fish from the fields L1-7/M2/N1-2 had lower SFA level in their meat (by 7.3 %) but higher MUFA concentration (by 5.8%) as compared to all other groups. Saturated fatty acids with odd number of C atoms – C15:0 and C17:0 which had no nutritional value, were under 1%.

Unsaturated fatty acids in the meat of the three studied groups of turbot were approximately 60% of the total FA content of meat lipids. This was in line with the results of Merdzhanova (2014) from the autumn catch of Black Sea turbot, as well as those of Guner et al. (1998) in other sea fish species as anchovies and whitings.

Within the MUFA group, predominating fatty acids were the oleic acid C18:1 ω-9 (for fish caught in fields L1-7/M2/N1-2), vaccenic acid C18:1 ω-7 (for fish caught in C17-E9 and E11-E13 fields), and palmitoleic acid (C16:1). The results showed difference with regard to the oleic acid content. Its average concentration in the meat of fish from the northern sector was by 73% higher than that from the southern sector (15.2-15.4%). The values of the palmitoleic acid varied within a narrowed range (6.9 - 8.9 %).

The polyunsaturated fatty acid group was presented with levels from 13.1 to 20.4 %, with higher contents in fish caught from the northern sector. Omega-6 fatty acids in turbot meat lipids from studied strata was determined at a higher extent by linoleic acid C18:2 ω-6 proportion (0.6-1.7 %) and a lesser extent, by linolenic acid (C18:3 ω-6) content.

Differences were observed with respect to the PUFA from the omega-3 group. Again, they were more in turbots from fields L1-7/M2/N1-2 (18.1 %) than in the other groups (13.9 % and 12.0 %). From the omega-3 fatty acids group, docosahexaenoic acid C22:6 ω-3 was the predominant one, with comparable values for C17-E9 and E11-E13– 10.1-11.9 %, and by 28.6 % higher for fish from fields L1-7/M2/N1-2 (15.3 %). At the same time, docosahexaenoic acid C22:6 ω-3 values were substantially higher than those of eicosapentaenoic C20:5 ω-3 acid – 1.9-4.2%. This is in agreement with the studies of other authors (Seibel and Drazen, 2007; Iverson, 2009), stating that in predatory fish, DHA level exceeded that of EPA while in fish feeding on plankton, the opposite relationship was seen: EPA > DHA. The most probable reason for this is that turbots are predatory fish from a higher trophic level of the food chain. Steffens and Wirt (2005) and Ackman (1994) affirm that long-chain fatty acids C20 and C22 are at a higher level in sea plankton. This explains the higher levels of C20:1 (3.3-4.7%) and C22:6 ω-3. According to Ugoala et al., (2008) and Abbas et al., (2009) sea fish species contained more docosahexaenoic 22:6 from the ω-3 group, while freshwater fish – more C18:2 and C20:4 from the ω-6 group of fatty acids.

Table 3. Individual fatty acid composition of turbot

FA*, %	Place of catch		
	C17 – E9	**E11 – E13**	**N1-2/M2/L1-7**
C 12:0	0.1	0.1	-
C 14:0	3.9	5.2	5.8
C 15:0	0.5	0.6	0.6
C 16:0	31.5	30.4	24.8
C 16:1	6.9	8.4	8.9
C 17:0	0.2	0.2	0.1
C 18:0	3.0	2.9	2.5
C 18:1 (ω-9)	15.4	15.2	26.7
C 18:1 (ω-7)	17.8	16.7	1.8
C 18:2 (ω-6)	0.6	0.9	1.7
C 18:3 (ω-6)	0.2	0.2	0.5
C 18:3 (ω-3)	-	-	0.4
C 20:1	4.1	4.7	3.3
C 20:2 (ω-6)	-	-	0.1
C 20:5 (ω-3)	2.0	1.9	2.4
C 22:0	1.9	2.5	4.2
C 22:1	-	-	0.8
C 22:6 (ω-3)	11.9	10.1	15.3
C 24:0	-	-	0.1
SFA	**41.1**	**41.9**	**38.1**
UFA	**58.9**	**58.1**	**61.9**
MUFA	**44.2**	**45.0**	**41.5**
PUFA	**14.7**	**13.1**	**20.4**
∑ω-6	**0.8**	**1.1**	**2.3**
∑ω-3	**13.9**	**12.0**	**18.1**
ω-6/ω-3	**0.06**	**0.09**	**0.13**

The higher levels of specific MUFA and PUFA in the meat lipids of fish groups from the northern Black Sea sector (L1-7/M2/N1-2) were most probably due to the species diversity and trophic level in the different studied fields and depths. This reflected on the biologically important omega-6/omega-3 ratio in fish, which ranged within 0.06-0.13. The fish from L1-7/M2/N1-2 had higher ratios than the other studied groups, with 1.4 to 2.1-fold differences.

The PUFA/SFA ratio calculated on the basis of fatty acid groups values (Table 3) varied from 0.38 to 0.54. According to the British Department of Health (1994) the minimum recommended value for this ratio is 0.45. Other researchers and sources (Kang and Leaf, 2000; FAO/WHO, 2008; EFSA, 2009) have set optimum value of 1.0 ± 0.2, therefore the recommended range of PUFA/SFA is from ≥ 0.45 to 1.0. According to our data, the fish caught in the northern Black Sea sector are within the recommended range (0.54). According to Simopolous (2013) values < 1.0 indicate a balanced distribution of fatty acid groups, as shown for other fish species from this sector.

CONCLUSIONS

The study provides evidence for specific differences in meat chemical composition and energy value of turbots caught from different localities in the northern and southern Black Sea sectors. A higher variation in protein content from 16.87 % (southern sector) to 19.32 % (northern sector) was observed as compared to meat fat contents range (1.29 - 2.08 %). With relation to fat content, fish from studied fields and sectors could be classified as the lean fish group.

It was demonstrated that according to the presence of the specific fatty acids, turbot meat lipids from fields C17-E9 and E11-E13 and trawling depth 36-53 m were of the palmitic type, whereas those from fish caught in L1-7/M2/N1-2, depth 52-64 m: of the oleic-palmitic type.

From the omega-3 fatty acid group, docosahexaenoic (C22:6 ω-3) acid in turbot meat lipids was at a higher amount than the eicosapentaenoic acid (C20:5 ω-3).

The biologically important ω-6:ω-3 ratio varied from 0.06 to 0.13, falling within the WHO range related to low risk for human health (<5.0).

The PUFA/SFA ratio in turbot lipids varied from 0.36 to 0.54, with a more balanced distribution for fatty acid groups in the meat of fish from the northern Black Sea sector (0.54).

According to the present study, Black Sea turbots caught in November 2014 from the northern sector (cape Galata, Kamchia and Shabla) at a depth of 52-64 m had higher absolute (19.32 %) and relative (89.49 %) meat protein contents, more balanced distribution of fatty acids (PUFA/SFA-0.54), higher unsaturated fatty acid content (61.9 %), including PUFA (20.4 %) and ω-3 (18.1 %) and more favorable ω-6:ω-3 ratio than respective values obtained from fish caught in the southern sector.

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