Int Aquat Res (2017) 9:313–327
https://doi.org/10.1007/s40071-017-0179-9

ORIGINAL RESEARCH

Determination of amino acid and fatty acid composition of goldband goatfish [*Upeneus moluccensis* (Bleeker, 1855)] fishing from the Gulf of Antalya (Turkey)

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Received: 12 March 2017 / Accepted: 23 September 2017 / Published online: 30 September 2017

Abstract In this study, we aimed to determine the basic food components, fatty acids and amino acids, and variations in these components with months in goldband goatfish (*Upeneus moluccensis*) that fishing from Gulf of Antalya. As a result of the analyzes, the crude fat values were determined between 1.43 and 3.78%, and the crude protein values were determined between 20.79 and 22.16%. The most abundant fatty acids were determined: palmitic acid (C16:0), stearic acid (C18:0), palmitoleic acid (C16:1c9), oleic acid (C18:1c9), linoleic acid (C18:2n-6), eicosatrienoic acid (C20:3n-3), arachidonic acid (C20:4n-6), eicosapentaenoic acid (C20:5n-3), docosapentaenoic acid (C22:5n-6), and docosahexaenoic acid (C22:6n-3). The most abundant amino acids were determined lysine and leucine, aspartic acid, glutamic acid, alanine, and glycine. The differentiations of essential nutrient components, fatty acids, and amino acids were found generally significant ($P < 0.05$).

Keywords Goldband goatfish · *Upeneus moluccensis* · Fatty acids · Amino acids · Food components · Catching season

Introduction

Seafood is a highly valuable food source because of rich in protein, amino acid, unsaturated fatty acid (especially omega-3), and vitamin components which are necessary for healthy and balanced nutrition (Gulyavuz and Unlusayın 1999; Simsek et al. 2009). The taste of fish meat is closely related to the protein and fat content, and also the seasonal variations of these components are important determinant of both consumer choice and quality of the processed product. Depending on the season, water temperature and nutrients in the environment affect the biochemical composition of fish meat (Kuzu 2005). In many studies, the relationship between seasonal changes and the chemical composition of fish meat has been shown (Ersoy 2006; Kandemir and Polat 2007; Polat et al. 2009; Ozogul et al. 2011). In a study, it was emphasized that the chemical composition of different fish species depends on variables such as seasonal change, migration, sexual maturity, and nutrient cyclicity (Kuzu 2005).

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Scientific studies in various fields reveal that nutrients and nutritional habits play an important role in some diseases that people are confronted with, and the necessity of more conscious nutrition is needed. A number of studies have been undertaken to elucidate the positive effect of fish consumption on human health and to investigate the therapeutic properties of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) found in seafood (Broughton et al. 1997; Haris 1997; Conquer et al. 2000; Norrish et al. 2000; Ozkan and Koca 2006; Ebbesson et al. 2008). EPA and DHA must be taken as essential fatty acids from the outside for a healthy life (Canbulat and Ozcan 2008).

Amino acids are determinants of quality in fish and crustaceans (Ruiz-Capillas and Moral 2001). Most amino acids such as glutamic acid, aspartic acid, alanine, and glycine are important, because they are responsible for the taste and flavor (Ruiz-Capillas and Moral 2004). Sea food is important source of protein because of the high content of aspartic acid, glutamic acid, lysine, arginine, and leucine (Rosa and Nunes 2003; Erkan and Ozden 2007). In fish, 50–80% of the non-protein nitrogenous compounds are amino acids and significant amounts of these are proline, arginine, lysine, alanine, histidine, glutamic acid, and taurine (Ruiz-Capillas and Moral 2001; Ozden 2005). The most consumed and delicious portions of fish are muscle tissue and they contain plenty of flavor amino acids. Amino acids provide tissue healing and growth (Oluwaniyi et al. 2010).

Although some studies have been published (Celik et al. 1999; Ersoy 2006; Simsek et al. 2009; Oksuz et al. 2011) about the fatty acid and the basic food components of the goldband goatfish (*Upeneus moluccensis*), but no information was found about the amino acid composition and seasonal study about the fatty acid and the basic food components of the goldband goatfish. In this study, the seasonal variation of the basic food components, amino acids, and fatty acids in goldband goatfish which were caught during the fishing season in Gulf of Antalya and have economic importance was investigated.

Materials and methods

Providing and preservation of samples

Sampling were conducted monthly during the catching season (September, October, November, December, January, February, March, and April). The goldband goatfish (*Upeneus moluccensis*) samples were purchased sufficient quantity at the time of reaching on port as the freshest state and brought to the Food Processing Laboratory of Egirdir Fisheries Faculty under cold chain conditions in 2 h. First, total length and weight measurements were determined and viscera were removed. The samples to be used in the determination of nutrient components were packed in the amount required for each analysis and stored at -80 ± 1 °C. 32 samples were used for each month. Female and male fish sample numbers were not considered.

Determination of the basic food components

Moisture analyzes of the samples were determined triplicate ($n = 3$) by an automatic moisture analyzer (AND MX-50 Moisture Analyzer, Japan). Crude ash analyzes were made triplicate ($n = 3$) according to AOAC (2002a), 920.153 Method. Crude protein analyzes were made duplicate ($n = 2$) according to AOAC (2010), 960.52 Micro Kjeldahl Method in the Turkey Scientific and Technical Research Institute Marmara Research Center (TUBITAK MAM).

Crude fat analyzes were made triplicate ($n = 3$) according to Lovell (1981). The glass containers to be used in the analyzes were first fixed weight. 5 g of sample placed in the tube were homogenized in a homogenizer (WiseTis HG-15D, Korea) with chloroform (Riedel–de–Haen, 24216), methanol (Riedel–de–Haen, 24229), and distilled water. The tubes were centrifuged (Sigma 2–16 K, Germany) at 3000 rpm for 10 min. At the end of the centrifugation, the methanol and water phase at the top, the fish meat phase in the middle, and the chloroform phase containing fat at the bottom were formed in the tubes. 1 mL was pipetted from the bottom chloroform phase and placed in fixed weight glass containers and evaporated in a hot water bath (WiseBath, Korea) for 1 h at 80° C. At last cooled to room temperature in the desiccator and weighed on a precision scale and the amount of crude fat was determined as %.

Determination of fatty acids

Fatty acid analyzes were made duplicate ($n = 2$) in Suleyman Demirel University (SDU) Experimental and Observational Student Research and Application Center. Fat extractions were made according to Bligh and Dyer (1959), methyl ester analyzes of fatty acids were made according to AOAC (2002b), 996.06 Method using gas chromatography (GC, Perkin Elmer Auto System XL, USA). After identifying 37 standard locations, Supelco 18919 F.A.M.E. Mix C4-C24, was injected into the GC. The fatty acids of the samples were determined in the reference assay conditions of AOAC 996.06.

Determination of amino acids

The amino acid analyzes of the samples were made duplicate ($n = 2$) in TUBITAK MAM according to Dimova (2003), and Gheshlaghi et al. (2008), using the high-performance liquid chromatography (HPLC) method. This method is based on the reading of ultra fast liquid chromatography–ultraviolet (UFLC-UV) detector by derivatization with phenyl isothiocyanate and acetonitrile:methanol:triethylamine solution after acidic hydrolysis applied to disassociate the constituent proteins into amino acid components. Tryptophan is completely disappeared as a result of acid hydrolysis; for that reason, tryptophan analyzes were made by base hydrolysis method. The sulfur-containing amino acids immediately expose to degradation when hydrolyzed with a strong acid solution, so sulfur-containing amino acids did not determine. Totally, 17 amino acids (aspartic acid, glutamic acid, serine, glycine, arginine, histidine, threonine, lysine, alanine, proline, leucine, isoleucine, tyrosine, phenylalanine, valine, methionine, and tryptophan) were determined as mg/100 g.

Statistical analyzes

The data, obtained in the study, were subjected to analysis of variance (F test) using the SPSS 16.0 program. Averages of significant variance sources were compared using the Duncan multiple comparison test as significance level $P = 0.05$.

Results and discussion

Average length and weight values

The monthly average of total length values was determined between 13.15 ± 0.12 cm and 14.89 ± 0.20 cm, and the monthly average weight values were determined between 24.98 ± 1.31 cm and 33.67 ± 1.34 g (Table 1). We intended that purchased fish should be about the same length and weight each month when sampling is being done. However, it was observed that the average length and weight values of fish purchased in September, February, and April were higher than the other months, depending on the fishing month, fishing area, feeding regime, and spawning season.

Proximate analyzes

Moisture

In our study, the moisture values of *U. moluccensis* samples were found between 78.74 ± 0.32 and 80.30 ± 0.45%, and there was no significant ($P > 0.05$) difference detected in monthly moisture change rates (Table 2).

The moisture content of seafood varies greatly with species, sex, and age. It is generally the moisture contents found between 70 and 85% in fish. This ratio decreases to 50–60% in some fishes (Gulyavuz and Unlusayın 1999). In the previous studies, the moisture contents of *Mullus barbatus* were determined 59.75% by Guner et al. (1998), 79.71% by Kalogeropoulos et al. (2004), and 79.00% by Gumus et al. (2009). Erkan et al. (2010b) determined the humidity value 70.25% in *Mullus surmuletus.* Oksuz et al. (2011), determined the humidity values 79.41% in *Upeneus moluccensis* and 73.14% in *M. surmuletus*. Ersoy (2006), found the

Table 1 Monthly average lengths and weights of *U. moluccensis*

	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	*P* values ($P < 0.05$)
Length (cm)	14.61 ± 0.20^{a}	13.15 ± 0.12^{c}	13.86 ± 0.19^{b}	$13.59 \pm 0.22b^{c}$	$13.39 \pm 0.11b^{c}$	14.89 ± 0.20^{a}	13.65 ± 0.17^{bc}	14.53 ± 0.14^{a}	0.000
Weight (g)	33.56 ± 1.12^{a}	25.19 ± 0.67^{c}	28.48 ± 1.15^{b}	24.98 ± 1.31^{c}	25.74 ± 0.59^{bc}	33.67 ± 1.34^{a}	26.79 ± 1.03^{bc}	33.31 ± 0.94^{a}	0.000

Different lowercase letters in the same line indicate significant differences ($P < 0.05$)

Table 2 Montly changes in the basic nutritional components of *U. moluccensis* (%)

	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	*P* values ($P < 0.05$)
Moisture	79.22 ± 0.52^{a}	78.97 ± 1.26^{a}	78.74 ± 0.32^{a}	78.89 ± 1.24^{a}	79.12 ± 0.50^{a}	79.75 ± 0.24^{a}	80.30 ± 0.45^{a}	79.90 ± 0.21^{a}	0.744
Crude ash	1.93 ± 0.09^{a}	1.82 ± 0.10^{ab}	1.86 ± 0.05^{ab}	1.61 ± 0.11^{b}	1.67 ± 0.07^{ab}	1.68 ± 0.08^{ab}	1.59 ± 0.11^{b}	1.65 ± 0.09^{b}	0.132
Crude fat	1.45 ± 0.01^{d}	3.08 ± 0.16^{b}	2.00 ± 0.06^{c}	3.54 ± 0.04^{a}	2.10 ± 0.12^{c}	2.12 ± 0.12^{c}	2.08 ± 0.09^{c}	3.78 ± 0.09^{a}	0.000
Crude protein	21.35 ± 0.04^{c}	21.50 ± 0.00^{bc}	21.22 ± 0.28^{cd}	21.60 ± 0.16^{bc}	22.16 ± 0.03^{a}	21.88 ± 0.07^{ab}	20.79 ± 0.10^{d}	20.82 ± 0.13^{d}	0.001

Different lowercase letters in the same line indicate significant differences ($P < 0.05$)

content of moisture in *U. moluccensis* between 75.79 and 78.27% in September, December, March, and May, and he indicated that these changes originated from the fish diet. Polat et al. (2009), found the changes in moisture content of *M. barbatus* in Autumn, Winter, and Spring seasons 74.13–75.21 and 73.84%, respectively, and they indicated that this changes originated from the feeding regime. Ozogul et al. (2011) investigated the changes in moisture content of *Upeneus pori* and *M. barbatus* seasonally. They determined the moisture contents between 75.31 and 79.08% in *U. pori* and between 76.23 and 76.92% in *M. barbatus*.

The moisture values were compared with the previous studies, it was observed that similar results were obtained in some studies (Kalogeropoulos et al. 2004; Gumus et al. 2009; Oksuz et al. 2011), and we found higher values than some studies (Guner et al. 1998; Erkan et al. 2010b; Polat et al. 2009; Tulgar and Berik 2012). We considered that the moisture value differentiations depend on species, season, nutritional regime, size, spawning season, sex, and catching area.

Crude ash

In our study, the crude ash was found between 1.59 ± 0.11 and 1.93 ± 0.09%. The highest crude ash was determined in September, and the lowest crude ash was determined in March (Table 2).

Gulyavuz and Unlusayın (1999) stated that the amount of inorganic matter in fish meat is about 1–2%. Aquatic organisms take inorganic materials from food and water, and store them in skeletal tissue and other members. There are many factors affecting the amount of inorganic matter such as season, biological difference (species, length, age, sex, and sexual maturity), nutrition, and environmental conditions (water chemistry, temperature, and salinity) (Cakli 2007). In the previous studies, the crude ash contents of *M. barbatus* were found 0.90% by Guner et al. (1998) and 1.45% by Gumus et al. (2009). Erkan et al. (2010b) determined the crude ash content 1.10% in *M. surmuletus*. Oksuz et al. (2011) found the crude ash content 1.10% in *U. moluccensis* and 1.60% in *M. surmuletus* and they were indicated that the difference is due to the mineral content of the species. Ersoy (2006) found the crude ash contents in the *U. moluccensis*, caught in September, December, March, and May, 1.29, 1.35, 1.24, and 1.38%, respectively. Polat et al. (2009) found that the crude ash contents of *M. barbatus* were 1.11% in Autumn, 1.09% in Winter, and 1.24% in Spring and they determined that seasonal variations were significant ($P < 0.05$). Ozogul et al. (2011) found the crude ash contents of *U. pori* between 1.42 and 1.65% and the crude ash contents of *M. barbatus* between 1.23 and 1.66%.

When we compared our values with the previous studies, we found that crude ash values are higher than the previous studies due to species, nutritional regime, and hunting area. In some studies (Polat et al. 2009; Oksuz et al. 2011; Tulgar and Berik 2012), seasonal variations were found generally significant ($P < 0.05$). We also found monthly variations generally significant ($P < 0.05$) and we thought that the monthly differences in our study depend on the spawning season, size, nutritional status, and catching area.

Crude fat

In our study, it was determined that the crude fat contents changed between 1.45 ± 0.01 and 3.78 ± 0.09%. The highest crude fat content was determined in April, before the spawning season, and the lowest crude fat was determined in September, after spawning season. The crude fat values were detected significantly ($P < 0.05$) higher in April and December and significantly ($P < 0.05$) lower in September than the other months (Table 2). We thought that the distinction in crude fat contents depends mainly on the spawning season, age, sex, and nutritional density.

In fish, the amount of fat may be below 1% and may exceed 30% according to the species and biological status and the fish are grouped according to the fat content (Cakli 2007). In addition, the fat content changes depending on the age, sex, catching season, nutritional status, and living environment (Gulyavuz and Unlusayın 1999).

In the previous studies, the crude fat contents of *M. barbatus* were determined 9.72% by Guner et al. (1998), 3.52% by Kalogeropoulos et al. (2004), and 1.75% by Gumus et al. (2009), and they considered them as low-fat fish. Celik et al. (1999) found that crude fat content was 6.67% in *M. barbatus*, 2.67% in *M. surmuletus,* and 4.91% in *U. moluccensis*. Erkan et al. (2010b) determined the crude fat content 14.46% in *M. surmuletus*. Oksuz et al. (2011) found that crude fat content was 4.35% in *U. moluccensis* and 10.38% in *M.*

surmuletus in their study. They noted that although the species belong to the same family and the same habitat, they may have distinct fat content. Ersoy (2006) investigated the nutrient composition of *U. Moluccensis* caught in September, December, March, and May and she determined the crude fat contents as 3.26, 0.64, 2.20, and 0.51%, respectively. Polat et al. (2009), in their study, determined the crude fat content of *M. barbatus* 3.68% in Spring, 5.33% in Winter, and 5.76% in Autumn. They thought that the fall in crude fat content during the spring season was to be due to the supply of raw energy needed for egg development during gonadogenesis formation, which reached the highest point just before the spawning. Ozogul et al. (2011) studied seasonally changes in crude fat content of *U. pori* and *M. barbatus* in their study. They determined the crude fat contents of *U. pori* between 1.07 and 2.10% and the crude fat contents of *M. barbatus* between 1.07 and 3.00%. They argued that the changes in fat rates are due to the season of feeding and spawning.

When we compared the fat content with the previous studies, we found similar results in some studies (Celik et al. 1999; Kalogeropoulos et al. 2004; Ersoy 2006; Gumus et al. 2009; Ozogul et al. 2011) and higher results in some studies (Guner et al. 1998; Erkan et al. 2010b; Oksuz et al. 2011). In general, significant ($P < 0.05$) variations were determined in seasonal studies (Polat et al. 2009; Tulgar and Berik 2012). We also found monthly variations generally significant ($P < 0.05$). We determined the *U. moluccensis* in the low-fat fish class according to the Cakli (2007).

Crude protein

In our study, we determined the crude protein content between 20.79 and 22.16%. The highest crude protein was determined in January, and the lowest crude protein was determined in March and April when the spawning period was near. Crude protein was detected in January significantly ($P < 0.05$) higher than other months, while crude protein values were detected in March and April significantly ($P < 0.05$) lower (Table 2). We thought that the differences in crude protein are mainly due to spawning season and nutritional density.

Gulyavuz and Unlusayın (1999) reported that the protein content of fish meat is about 14–20%, and this values changes with age, gender, feeding environment, spawning, and migration season. Cakli (2007) also reported that protein contents of aquatic organisms are about 11–25%. In the previous studies, the crude protein contents of *M. barbatus* were determined 16.3% by Guner et al. (1998), 14.79% by Kalogeropoulos et al. (2004), and 14.84% by Gumus et al. (2009). Celik et al. (1999) found crude protein contents 21.32% in *M. barbatus,* 19.56% in *M. surmuletus,* and 20.32% in *U. moluccensis*. Erkan et al. (2010b) determined the crude protein content 14.07% in *M. surmuletus*. Ersoy (2006) investigated the nutrient composition of the *U. moluccensis* fillets in September, December, March, and May and determined crude protein contents as 19.32, 21.00, 18.75, and 19.36%, respectively. She stated that the protein contents changed depending on the catching season and the feeding density. Polat et al. (2009) found that the crude protein content of *M. barbatus* was 20.43% in Spring, 17.90% in Winter, and 18.97% in Autumn. The amount of crude protein in the spring, before spawning period, was significantly higher than other seasons ($P < 0.05$). Ozogul et al. (2011) found that the crude protein contents of *U. pori* were between 17.68 and 21.27% and the crude protein contents of *M. barbatus* were between 18.25 and 20.52% in their studies. They found the lowest protein contents in both species in Spring.

When we compared the our protein values with the previous studies, similar results were appeared in some studies (Celik et al. 1999; Ersoy 2006) and lower protein values were appeared in some studies (Guner et al. 1998; Kalogeropoulos et al. 2004; Gumus et al. 2009; Tulgar and Berik 2012). In seasonal studies (Ersoy 2006; Polat et al. 2009; Ozogul et al. 2011; Tulgar and Berik 2012), generally significantly ($P < 0.05$) different values were determined as our monthly study. When we examined the crude protein values of the *U. moluccensis* in our study, we concluded that it was an important protein source in all months (although the protein contents decreased in March and April when the spawning season approached).

Fatty acids

In our study, it was observed that the monthly variations of fatty acid values of *U. moluccensis* samples are generally significant ($P < 0.05$). We found that the most abundant fatty acids were palmitic acid and stearic acid as saturated fatty acids, palmitoleic acid and oleic acid as monounsaturated fatty acids, eicosatrienoic acid, arachidonic acid, EPA, and DHA as polyunsaturated fatty acids (Table 3).

Table 3 Montly changes in fatty acid contets of *U. moluccensis* (% total fatty acids)

Fatty acids	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	*P* values ($P < 0.05$)
C14:0	2.43 ± 0.11^{b}	2.08 ± 0.16^{bc}	2.88 ± 0.02^{a}	2.87 ± 0.15^{a}	2.06 ± 0.12^{bc}	2.16 ± 0.08^{bc}	2.18 ± 0.14^{bc}	1.81 ± 0.10^{c}	0.001
C15:0	0.89 ± 0.02^{ab}	0.73 ± 0.04^{c}	1.00 ± 0.01^{a}	1.00 ± 0.04^{a}	0.99 ± 0.05^{a}	0.88 ± 0.01^{b}	0.91 ± 0.05^{ab}	0.90 ± 0.02^{ab}	0.004
C16:0	20.46 ± 0.32^{c}	24.33 ± 0.67^{a}	24.10 ± 0.05^{a}	24.86 ± 0.55^{a}	21.12 ± 0.59^{bc}	21.28 ± 0.08^{bc}	20.58 ± 0.028^{c}	22.07 ± 0.09^{b}	0.000
C17:0	1.96 ± 0.01^{c}	1.70 ± 0.02^{d}	2.10 ± 0.05^{b}	2.30 ± 0.02^{a}	2.04 ± 0.03^{bc}	2.03 ± 0.02^{bc}	2.37 ± 0.05^{a}	2.00 ± 0.02^{bc}	0.000
C18:0	8.89 ± 0.04^{b}	7.09 ± 0.07^{e}	7.40 ± 0.10^{d}	8.29 ± 0.03^{c}	8.53 ± 0.02^{c}	9.16 ± 0.18^{a}	8.82 ± 0.02^{b}	7.38 ± 0.03^{d}	0.000
C21:0	0.51 ± 0.02^{c}	0.48 ± 0.01^{cd}	0.44 ± 0.01^{de}	0.40 ± 0.02^{e}	0.34 ± 0.01^{f}	0.60 ± 0.02^{b}	0.65 ± 0.01^{a}	0.65 ± 0.03^{a}	0.000
∑SFA	35.14 ± 0.40^{a}	36.41 ± 0.80^{bc}	37.92 ± 0.09^{b}	39.72 ± 0.74^{a}	35.08 ± 0.77^{a}	36.11 ± 0.22^{a}	35.51 ± 0.07^{a}	34.81 ± 0.13^{a}	0.001
C14:1	0.16 ± 0.01^{de}	0.23 ± 0.01^{a}	0.18 ± 0.01^{cd}	0.20 ± 0.01^{bc}	0.22 ± 0.2^{ab}	0.15 ± 0.01^{ef}	0.12 ± 0.00^{f}	0.19 ± 0.01^{bcd}	0.000
C16:1	3.38 ± 0.05^{d}	7.33 ± 0.12^{a}	6.70 ± 0.12^{ab}	5.52 ± 0.15^{c}	5.64 ± 0.41^{c}	4.58 ± 0.03^{d}	5.11 ± 0.25^{cd}	6.31 ± 0.19^{b}	0.000
C17:1	0.85 ± 0.11^{b}	0.67 ± 0.03^{c}	1.22 ± 0.03^{a}	1.09 ± 0.01^{a}	0.82 ± 0.02^{bc}	1.11 ± 0.01^{a}	1.10 ± 0.02^{a}	0.77 ± 0.06^{bc}	0.000
C18:ln9c	13.37 ± 0.05^{d}	19.10 ± 0.05^{a}	18.20 ± 0.26^{b}	17.64 ± 0.49^{b}	19.13 ± 0.01^{a}	17.70 ± 0.29^{b}	14.91 ± 0.09^{c}	19.09 ± 0.07^{a}	0.000
C20:1	0.61 ± 0.04^{de}	0.90 ± 0.07^{b}	0.66 ± 0.01^{de}	0.82 ± 0.02^{bc}	1.27 ± 0.01^{a}	0.67 ± 0.03^{de}	0.73 ± 0.05^{cd}	0.61 ± 0.02^{e}	0.000
∑MUFA	18.37 ± 0.07^{f}	28.23 ± 0.14^{a}	26.96 ± 0.41^{b}	25.27 ± 0.34^{c}	27.08 ± 0.43^{b}	24.21 ± 0.27^{d}	21.97 ± 0.23^{e}	26.97 ± 0.06^{b}	0.000
C18:2n6r	0.45 ± 0.01^{d}	1.12 ± 0.10^{a}	0.69 ± 0.01^{c}	0.53 ± 0.05^{d}	0.96 ± 0.01^{b}	0.68 ± 0.01^{c}	0.84 ± 0.01^{b}	0.88 ± 0.03^{b}	0.000
C18:2n6c	1.17 ± 0.02^{b}	1.67 ± 0.01^{a}	1.12 ± 0.02^{c}	1.06 ± 0.00^{d}	1.02 ± 0.00^{d}	1.17 ± 0.02^{b}	1.05 ± 0.01^{d}	1.18 ± 0.03^{b}	0.000
C18:3n6	0.58 ± 0.00^{cd}	0.37 ± 0.03^{d}	0.53 ± 0.01^{cd}	0.64 ± 0.01^{c}	0.96 ± 0.01^{b}	0.72 ± 0.07^{c}	1.15 ± 0.17^{b}	1.39 ± 0.03^{a}	0.000
C18:3n3	0.56 ± 0.06^{c}	0.54 ± 0.02^{c}	0.61 ± 0.01^{bc}	0.74 ± 0.02^{a}	0.66 ± 0.02^{abc}	0.55 ± 0.01^{c}	0.71 ± 0.08^{ab}	0.57 ± 0.01^{c}	0.028
C20:3 n6	0.70 ± 0.01^{a}	0.11 ± 0.01^{d}	0.10 ± 0.01^{d}	0.06 ± 0.01^{d}	0.21 ± 0.03^{c}	0.74 ± 0.06^{a}	0.78 ± 0.01^{a}	0.53 ± 0.02^{b}	0.000
C20:3 n3	4.14 ± 0.07^{b}	2.79 ± 0.05^{ef}	2.85 ± 0.01^{e}	2.68 ± 0.05^{fg}	3.46 ± 0.05^{d}	4.36 ± 0.04^{a}	3.84 ± 0.05^{c}	2.60 ± 0.02^{g}	0.000
C20:4 n6	5.40 ± 0.08^{d}	6.40 ± 0.09^{a}	6.48 ± 0.01^{a}	6.50 ± 0.08^{a}	6.06 ± 0.07^{b}	4.55 ± 0.02^{e}	5.77 ± 0.06^{c}	4.62 ± 0.05^{e}	0.000
C20:5 n3	2.02 ± 0.06^{b}	1.69 ± 0.09^{cd}	1.61 ± 0.04^{de}	1.45 ± 0.02^{e}	1.88 ± 0.10^{bc}	1.78 ± 0.01^{cd}	2.05 ± 0.06^{b}	2.33 ± 0.07^{a}	0.000
C22:5 n6	1.94 ± 0.03^{a}	1.14 ± 0.04^{e}	1.22 ± 0.03^{e}	1.34 ± 0.02^{d}	1.42 ± 0.04^{d}	1.91 ± 0.02^{ab}	1.83 ± 0.05^{b}	1.70 ± 0.02^{c}	0.000
C22:6 n3	26.09 ± 0.47^{a}	15.15 ± 0.37^{e}	17.11 ± 0.46^{cd}	17.39 ± 0.24^{c}	17.07 ± 0.65^{cd}	20.83 ± 0.01^{b}	18.09 ± 0.03^{c}	15.96 ± 0.08^{de}	0.000
∑PUFA	43.05 ± 0.62^{a}	30.98 ± 0.72^{d}	32.32 ± 0.55^{cd}	32.39 ± 0.37^{cd}	33.70 ± 0.97^{c}	37.29 ± 0.18^{b}	36.11 ± 0.02^{b}	31.76 ± 0.08^{d}	0.000
TOTAL	96.53 ± 0.16^{b}	95.50 ± 0.27^{c}	97.15 ± 0.06^{a}	97.32 ± 0.03^{a}	95.82 ± 0.24^{c}	97.54 ± 0.13^{a}	93.53 ± 0.19^{d}	93.48 ± 0.15^{d}	0.000
Unidentified	3.48 ± 0.16^{c}	4.50 ± 0.27^{b}	2.86 ± 0.06^{d}	2.68 ± 0.03^{d}	4.19 ± 0.24^{b}	2.47 ± 0.13^{d}	6.48 ± 0.19^{a}	6.53 ± 0.15^{a}	0.000
∑UNSFA	61.42 ± 0.56^{a}	59.21 ± 0.58^{b}	$59.28 \pm 0{,}14^{b}$	57.66 ± 0.71^{c}	60.78 ± 0.54^{a}	61.50 ± 0.09^{a}	58.08 ± 0.25^{bc}	58.73 ± 0.02^{bc}	0.001
∑UNSFA/ESFA	1.75 ± 0.04^{a}	1.63 ± 0.05^{b}	1.56 ± 0.01^{bc}	1.45 ± 0.05^{c}	1.73 ± 0.06^{a}	1.70 ± 0.02^{a}	1.64 ± 0.01^{b}	1.69 ± 0.01^{3}	0.004
EPA + DHA	28.11 ± 0.53^{a}	16.84 ± 0.46^{e}	18.72 ± 0.50^{cd}	18.84 ± 0.26^{cd}	18.95 ± 0.75^{cd}	22.61 ± 0.00^{b}	20.14 ± 0.09^{c}	18.29 ± 0.01^{d}	0.000
n3PUFA	32.81 ± 0.53^{a}	20.17 ± 0.52^{f}	22.18 ± 0.52^{de}	22.26 ± 0.32^{de}	23.07 ± 0.82^{d}	27.52 ± 0.04^{b}	24.69 ± 0.05^{c}	21.46 ± 0.05^{ef}	0.000
n6PUFA	10.24 ± 0.09^{d}	10.81 ± 0.21^{b}	10.14 ± 0.03^{de}	10.13 ± 0.05^{de}	10.63 ± 0.16^{bc}	9.77 ± 0.14^{e}	11.42 ± 0.07^{a}	10.30 ± 0.04^{cd}	0.000
n6/n3	0.31 ± 0.00^{e}	0.54 ± 0.01^{a}	0.46 ± 0.01^{bc}	0.46 ± 0.01^{c}	0.46 ± 0.01^{bc}	0.36 ± 0.01^{d}	0.46 ± 0.01^{bc}	0.48 ± 0.00^{b}	0.000

Table 3 continued

Fatty acids	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	*P* values ($P < 0.05$)
$\sum$PUFA/ESFA	1.23 ± 0.04^{a}	0.85 ± 0.04^{d}	0.85 ± 0.02^{d}	0.82 ± 0.03^{d}	0.96 ± 0.05^{bc}	1.03 ± 0.00^{b}	1.02 ± 0.01^{b}	0.91 ± 0.00^{cd}	0.000

Different lowercase letters in the same line indicate significant differences ($P < 0.05$)

$\sum SFA$ total saturated fatty acids, $\sum MUFA$ total monounsaturated fatty acids, $\sum PUFA$ total polyunsaturated fatty acids, $\sum UNSFA$ total unsaturated fatty acids

The beneficial effects of fish fat on human health are known. Polyunsaturated fatty acids (especially omega-3) have been recognized as essential components of human food for the prevention of illness and a healthy life. There is a serious deficiency about intake of ω-3 polyunsaturated fatty acid (PUFA) in human beings, for that reason to consume more foods that containing these fatty acids is recommended (Erkan 2013). In the previous studies, Guner et al. (1998) found the major fatty acids in *M. barbatus* were palmitic acid, palmitoleic acid, stearic acid, oleic acid, EPA, docosapentaenoic acid (DPA, C22:5n-6) and DHA. They stated that the amount of crude fat and fatty acids must be taken into account when determining the nutritional value of fish. Kalogeropoulos et al. (2004) found the major fatty acids in *M. barbatus* were palmitic acid, palmitoleic acid, oleic acid, EPA, and DHA. Polat et al. (2009) determined that the predominant fatty acids were palmitic acid, stearic acid, oleic acid, palmitoleic acid, EPA, and DHA in *M. barbatus* in all seasons, and they reported that fatty acid components were varied with season and the amount of DHA + EPA and affects consumer preferences positively. Ozogul et al. (2011) found that the fatty acids of *U. pori* and *M. barbatus* were seasonally changed by a number of ecological and biological effects, and EPA and DHA values were high in all seasons. Oksuz et al. (2011) found that the most abundant fatty acids in *U. moluccensis* and *M. surmuletus* were palmitic acid, stearic acid, oleic acid, palmitoleic acid, EPA, and DHA. They reported the amount of omega-3 more than the amount of omega-6 in both species important for human health. Erkan (2013) studied omega-3 fatty acid distribution of consumed aquatic products in Turkey and found that the most abundant fatty acids in fish fat were palmitic acid, stearic acid, palmitoleic acid, oleic acid, EPA, and DHA.

When we compared with the previous studies, it was seen that similar results were detected the most abundant fatty acids. It was also found that the unsaturated fatty acid values were between 57.66 and 61.50% (Table 3) and these values were determined similar to the previous studies. It has been determined that the fatty acid content of fish fat changes in a number of studies (Gamez-Meza et al. 1999; Luzia et al. 2003; Kuzu 2005; Polat et al. 2009; Ozogul et al. 2011). Seasonal conditions, age, size, catching area, and spawning period have been shown as the reason for the change. In our study, we were also considered that the above-mentioned factors influence the distinctions in fatty acid amounts.

Amino acids

In our study, 17 amino acids were detected in the *U. moluccensis* samples. The amino acid contents of the samples changed monthly. We found that the most abundant amino acids were lysine and leucine as essential amino acids, aspartic acid, glutamic acid, alanine, and glycine as non-essential amino acids. When the total amino acid values were examined, it was determined that the highest amount of amino acid was found in December, and the lowest amount of amino acids were found in near spawning months (April and September). Monthly changes in the amounts of amino acids were found generally significant ($P < 0.05$) (Table 4). We thought that the monthly changes are caused by seasonal conditions, age, size, catching area, spawning season, and feeding conditions.

Fish are known to have high protein content and the most abundant amino acids are glutamic acid, aspartic acid, and lysine in aquatic organisms (Ozden and Erkan, 2008). In the previous studies, Kim and Lall (2000) investigated the amino acid contents of three kinds of marine flounder fish (*Hippoglossus hippoglossus*, *Pleuronectes ferruginea,* and *Paralichthys olivaceus*) in their study and found that the most abundant amino acids are aspartic acid, glutamic acid, glycine, leucine, and lysine. Zuraini et al. (2006) studied the amino acid contents of *Channa striats*, *Channa micropeltes,* and *Channa lucius*. They determined that the most abundant amino acids are glutamic acid, aspartic acid, and lysine, and they indicated that these species are rich about essential amino acids for human health and evolution. Ozden and Erkan (2008) examined the amino acid contents of three cultured species (*Dicentrarchus labrax*, *Sparus aurata*, and *Dentex dentex*) and determined that aspartic acid, glutamic acid, and lysine were the most abundant amino acids. They reported that aspartic acid and glutamic acid are important in enzyme solubility and protecting ionic character in enzyme activity. Adeyeye (2009), in his study, examined the amino acid contents of *Clarias anguillaris*, *Oreochromis niloticus,* and *Cynoglossus senegalensis* species, and he identified that glutamic acid, aspartic acid, and leucine were most common amino acids. He reported that these species are valuable amino acid sources. Erkan et al. (2010a) examined the amino acid content of *Trachurus trachurus* and found that the most abundant amino acids were aspartic acid, glutamic acid, and lysine. Erkan et al. (2010b) studied about the amino acid contents of *Engraulis encrasicolus*, *Pomatomus saltatrix*, *Sarda sarda*, *M. surmelutus,* and *Merlangius merlangus* and

Table 4 Montly changes in amino acid contents of *U. moluccensis* (mg/l00 g)

Amino acids	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	P values ($P < 0.05$)
Met.	500.5 ± 8.5^{e}	549.5 ± 2.5^{d}	512.5 ± 6.5^{e}	676.0 ± 6.0^{a}	603.5 ± 2.5^{c}	634.0 ± 2.0^{b}	507.0 ± 1.0^{e}	$422.5 \pm 0..5^{f}$	0.000
Phe.	714.5 ± 12.5^{e}	826.5 ± 7.5^{c}	747.0 ± 12.0^{d}	974.0 ± 11.0^{a}	910.5 ± 7.5^{b}	901.5 ± 5.5^{b}	746.5 ± 4.5^{d}	585.5 ± 0.5^{f}	0.000
Lys.	2571.0 ± 59.0^{e}	2933.5 ± 31.5^{c}	2744.5 ± 51.5^{d}	4638.0 ± 68.0^{a}	2259.5 ± 22.5^{f}	3821.5 ± 42.5^{b}	2688.0 ± 21.0^{de}	2621.5 ± 11.5^{de}	0.000
Val.	767.5 ± 13.5^{e}	872.0 ± 5.0^{c}	817.5 ± 12.5^{d}	1045.5 ± 10.5^{a}	957.0 ± 7.0^{b}	953.5 ± 16.0^{b}	726.0 ± 10.0^{f}	611.0 ± 2.0^{g}	0.000
Leu.	1249.0 ± 21.0^{e}	1424.5 ± 23.5^{c}	1343.0 ± 3.0^{d}	1769.0 ± 16.0^{a}	1621.5 ± 23.5^{b}	1622.0 ± 7.0^{b}	1308.5 ± 3.5^{d}	1069.5 ± 0.5^{f}	0.000
lie.	907.5 ± 16.5^{e}	1047.0 ± 9.0^{c}	990.5 ± 11.5^{d}	1286.0 ± 10.0^{a}	1200.0 ± 10.0^{b}	1180.5 ± 4.5^{b}	915.0 ± 6.0^{e}	771.0 ± 1.0^{f}	0.000
Thr.	849.0 ± 14.0^{e}	1096.5 ± 4.5^{c}	1106.5 ± 13.5^{c}	1038.5 ± 4.5^{d}	1250.0 ± 6.0^{a}	1205.5 ± 2.5^{b}	695.0 ± 2.0^{g}	774.0 ± 0.0^{f}	0.000
Tip.	226.0 ± 2.0^{abc}	232.0 ± 1.0^{ab}	241.5 ± 1.5^{a}	212.0 ± 3.0^{c}	239.5 ± 9.5^{a}	232.0 ± 6.0^{ab}	233.0 ± 2.0^{ab}	221.0 ± 4.0^{bc}	0.023
Arg.	491.0 ± 8.0^{g}	439.5 ± 10.5^{h}	547.0 ± 16.0^{f}	898.0 ± 9.0^{e}	1254.5 ± 4.5^{d}	1609.5 ± 4.5^{a}	1287.5 ± 5.5^{c}	1474.5 ± 3.5^{b}	0.000
His.	575.5 ± 16.5^{d}	750.5 ± 5.5^{b}	766.5 ± 8.5^{b}	841.0 ± 7.0^{a}	708.5 ± 4.5^{c}	751.0 ± 4.0^{b}	435.5 ± 1.5^{f}	499.0 ± 0.0^{e}	0.000
Ala.	971.5 ± 15.5^{de}	1085.0 ± 3.0^{c}	996.5 ± 12.5^{d}	1325.5 ± 6.5^{a}	1101.0 ± 4.0^{c}	1208.5 ± 7.5^{b}	957.5 ± 6.5^{e}	809.0 ± 1.0^{f}	0.000
Asp.	766.5 ± 12.5^{g}	1591.5 ± 8.50^{c}	1133.5 ± 14.5^{f}	1862.5 ± 8.5^{b}	1112.0 ± 3.0^{f}	2221.5 ± 12.5^{a}	1335.5 ± 4.5^{e}	1476.0 ± 6.0^{d}	0.000
Glu.	1422.0 ± 23.0^{g}	2023.5 ± 8.5^{c}	1668.5 ± 18.5^{e}	2709.0 ± 11.0^{a}	1484.5 ± 4.5^{f}	2637.0 ± 10.0^{b}	1864.5 ± 4.5^{d}	1992.5 ± 6.5^{c}	0.000
Tyr.	565.5 ± 15.5^{e}	648.5 ± 8.5^{c}	601.0 ± 10.0^{d}	756.5 ± 9.5^{a}	711.0 ± 7.0^{b}	720.0 ± 6.0^{b}	564.5 ± 4.5^{e}	458.0 ± 1.0^{f}	0.000
Gly.	1006.0 ± 18.0^{d}	1070.0 ± 4.0^{c}	951.5 ± 11.5^{e}	1276.0 ± 7.0^{a}	948.5 ± 3.5^{e}	1137.5 ± 3.5^{b}	943.5 ± 4.5^{e}	796.0 ± 4.0^{f}	0.000
Ser.	679.5 ± 13.5^{f}	877.5 ± 3.5^{c}	819.5 ± 9.5^{d}	966.0 ± 5.0^{b}	785.0 ± 4.0^{e}	1045.0 ± 3.0^{a}	$621. \pm 1.0^{g}$	620.0 ± 0.0^{g}	0.000
Pro.	711.5 ± 9.5^{e}	728.5 ± 0.5^{d}	649.0 ± 7.0^{f}	873.0 ± 4.0^{b}	785.0 ± 2.0^{c}	997.5 ± 3.5^{a}	733.5 ± 1.5^{d}	604.5 ± 0.5^{g}	0.000
Total	$14,974.0 \pm 275.0^{e}$	$18,196.0 \pm 137.0^{b}$	$16,636.0 \pm 217.0^{c}$	$23,146.5 \pm 190.5^{a}$	$17,931.5 \pm 125.5^{b}$	$22,878.0 \pm 129.0^{a}$	$16,562 \pm 81.0^{c}$	$15.805.5 \pm 7.5^{d}$	0.000

Different lowercase letters in the same line indicate significant differences ($P < 0.05$)

they found that lysine, leucine, arginine, glutamic acid, and aspartic acid were the most abundant amino acids. Oluwaniyi et al. (2010) studied about the amino acid contents of *Clupea harengus*, *Scomber scombrus*, *Trachurus trachurus,* and *Urophycis tenuis* species. They reported that the most abundant amino acids are glutamic acid, aspartic acid, lysine, and leucine. Zhao et al. (2010) studied about the amino acid content of *Pampus punctatissimus*, an important fishery source in China, and found that glutamic acid, lysine, leucine, and aspartic acid were the most abundant amino acids. Ozden and Erkan (2011) studied the amino acid contents of some fishery products and found that the amino acid values changes according to species. Peng et al. (2013), identified that the most abundant amino acids of in tuna fish (*Thunnus albacares* and *Thunnus obesus*) were aspartic acid, glutamic acid, and lysine. They stated that the named fish are a good source of nutrients in terms of glutamic acid that required for cell proliferation. Kaya et al. (2014) investigated the amino acid content of, *Salmo trutta forma fario* that hunting and growing on the farms, and they found that glutamic acid, aspartic acid, and lysine values were higher than other amino acids. They found that the differences in total amino acid values were generally significant ($P < 0.05$) by species and by age, and they stated that the distinction in amino acid values was due to the spawning season, the feeding conditions, and the living area. Baki et al. (2015), compared the amino acid contents of natural and cultured sea bass (*Dicentrarchus labrax*) in their study, and they found that the most abundant amino acids were aspartic acid, glutamic acid, leucine, and lysine. Suseno (2015) reported that the most abundant amino acids were glutamic acid, arginine, leucine, and lysine in tuna fish (*Thunnus* sp.). Salma et al. (2016) found that the most abundant amino acids found in mackerel (*Scomber scombrus*) were glutamic acid, aspartic acid, and lysine.

We did not detect any study about amino acid contents of *U. moluccensis*. For that reason, we studied the work done with different types of fish and we found similar results for the most abundant amino acids. When we compared with the previous studies, we thought that the different results may be due to seasonal, biological differences, nutritional, and environmental conditions as well as methods used for amino acid determination. In addition, Kaya et al. (2014) found significant differences in monthly amino acid values in their studies ($P < 0.05$) like us.

Oluwaniyi et al. (2010) compared the essential amino acid contents of *C. harengus, S. scombrus, T. trachurus,* and *U. tenuis* with the standard amino acid values of FAO/WHO (1991). They determined that the essential amino acid values of the stated species were higher than the standard amino acid values, and according to these values, indicated species are a good source of amino acid. Zhao et al. (2010) compared the essential amino acid content of *P. punctatissimus* with the reference amino acid values of FAO/WHO/UNU (1985) and determined that the essential amino acid values of *P. punctatissimus* were higher than the reference values. Peng et al. (2013) compared the amino acid content of *T. albacares* and *T. obesus* with the standard amino acid values of FAO/WHO (1991) and found that the essential amino acid values of these species were higher than the standard amino acid values. They reported that the the essential amino acids of stated species were above the level required by humans by age. In our study, were compared the our 8-month averages of amino acid values in *U. moluccensis* with the average amino acid values of FAO (2013), and we determined that *U. moluccensis* has significant portion of the required amount of essential amino acids (Table 5).

Table 5 Comparison of the essential amino acid contets of *U. moluccensis* with the reference essential amino acid requirement according to FAO (2013), age groups

Amino acids (mg/g)	Reference amino acid values (FAO 2013)			Average amino acid content of *U. moluccensis* for 8 months
	Infant (0–6 month)	Child(6 month–3 year)	Older child, adolescent, adult	
His.	21	20	16	6.7
Iie.	55	32	30	10.4
Leu.	96	66	61	14.3
Lys.	69	57	48	30.3
Met.+Cys.	33	27	23	5.5
Phe.+Tyr.	94	52	41	14.3
Thr.	44	31	25	10.0
Trp.	17	8.5	6.6	2.3
Val.	55	43	40	8.4

Compared with the previous studies (Oluwaniyi et al. 2010; Zhao et al. 2010; Peng et al. 2013), lower essential amino acid values were detected in our study. It is thought that this may be due to seasonal, biological differences, nutritional, and environmental conditions as well as methods used for amino acid determination.

Conclusions

Our study showed that the basic food components, fatty acids, and amino acid values changes by monthly and the amounts of these changes were found generally significant ($P < 0.05$). We thought that these changes were influenced by many factors such as season, biological difference (species, height, age, sex, and sexual maturity), nutrition, and environmental conditions (water chemistry, temperature, and salinity). We also concluded that *U. moluccensis* is an important food source of the basic nutrients, fatty acids, and amino acid values in all fishing seasons.

Acknowledgements We acknowledge to Suleyman Demirel University Scientific Research Projects Coordination Unit for contributions to our Project of which No. is 4451-1-15.

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