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RESEARCH ARTICLE **ARAŞTIRMA MAKALESİ**

Determination of amino acid and fatty acid profiles of bogue (*Boops boops*) fished in the Gulf of Antalya

Antalya Körfezi'nden avlanan kupes (*Boops boops*)'in amino asit ve yağ asidi özelliklerinin belirlenmesi

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Abstract: Our study aimed to establish the monthly changes of bogue fatty acids and amino acids (*Boops boops* Linnaeus, 1758) economically important species during the fishing season. According to the results of the fatty acid analysis of bogue; the highest values were detected for C20:4 ω-6 (arachidonic acid) in December (6.50%), EPA (eicosapentaenoic acid) C20:5 ω-3 in September (5.45%), DHA (docosahexaenoic acid) C22:6 ω-3 in March (16.36%), ΣMUFA (total monounsaturated fatty acid) in April (36.57%), ΣPUFA (total polyunsaturated fatty acid) in November (31.81%) and EPA+DHA in March (19.61%). The highest EPA, DHA and total ω-3 values were observed in March. Amino acid values usually showed important monthly variation ($P<0.05$). EAA (Essential amino acids) such as lysine (4038.5 mg/100g), valine (1126.5 mg/100g) and leucine (1737.5 mg/100g) contents of bogue were detected in February as the highest values. Glutamic acid and aspartic acid from the NEAA (Non-essential amino acid) values were found highest amount in April. Fatty acids and amino acid values, obtained from the bogue samples changed monthly and were generally significant ($P<0.05$).

Keywords: *Boops boops*, fatty acids, amino acids, bogue, season

INTRODUCTION

Amino acids are qualification indicators in fish and crustaceans (Ruiz-Capillas and Moral, 2001). Important amino acids for taste and aroma are glutamic acid, alanine, aspartic acid and glycine (Ruiz-Capillas and Moral, 2004). Fish are important sources of protein in that they contain aspartic acid, glutamic acid, lysine, arginine and leucine amino acids in large amounts (Rosa and Nunes, 2003; Erkan and Özden, 2007). Muscles are the most eaten up and tasty part of fish and include a significant amount of aromatic components and amino acids. Amino acids have important roles in the body improvement and development (Oluwaniyi et al., 2010).

Linoleic acid, linolenic acid, arachidonic acid, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are known as essential fatty acids, and since these fatty acids cannot be synthesized by animal creatures, they must be taken from the diet (Gogus and Smith, 2010). EPA (C20:5, ω-3), decosapentaenoic acid (DPA) (C22:5, ω-3) and DHA (C22:6, ω-3), which are the most important omega-3 fatty acids, are abundant in fish (Gogus and Smith, 2010).

Bogue (from Sparidae), which is known to be distributed in all our seas (Bilecenoğlu et al., 2014; Demirkesen, 2015), is a commercially important fish for countries with a Mediterranean coast (Bogdanovic et al., 2012; Soykan et al., 2015). It is exported to European countries, particularly in winter (Cengiz et al., 2019).

Even though there are studies on the determination of Bogue's fatty acids and amino acids (Passi et al., 2002; Kalogeropoulos et al., 2004; Özogul and Özogul, 2007; Diraman and Dibeklioglu, 2009; Zotos and Vouzanidou, 2011; Ciampa et al., 2012; Prato and Biandolino, 2012; Simat et al., 2012; Morales-Medina et al., 2015; Simat et al., 2015; Miçooğulları, 2017; Uçar, 2020), few studies have been done on the monthly change of nutritional composition. In this study, the monthly fluctuations in amino acids and fatty acids of bogue, caught in Antalya Bay and has economic significance, were examined.

MATERIALS AND METHODS

Sample collection and storage

In the notification numbered 5/1 regulating commercial fishing published by the Ministry of Agriculture and Forestry in 2020, there is no period and length restriction for bogue fishing (No: 2020/20). Despite this, fishermen prefer to fish during the general fishing season to avoid any sanctions during fishing periods. For this reason, sampling studies were carried out monthly during the 2019-2020 (September 1st-April 15th) fishing season. Bogue samples were obtained from trawlers who fished in Antalya Bay between the 1st of September and the 15th of April. The freshest samples were purchased from fishermen in Antalya Fishing Port and transported to the laboratory (Isparta University of Applied Sciences Eğirdir Faculty of Fisheries Food Processing Laboratory) in iced styrofoam boxes with a ratio of 1/3 ice/fish within 2 hours.

The total length precision of each specimen was measured ±0.1 cm and body weight was measured ±0.1 g. The internal organs of the fish were then removed. The samples were packaged in enough (5 pieces) ziplock plastic bags for each test and labeled, then preserved at -80±1°C (Daihan Digital Ultra Low-Temperature Freezer, South Korea). No distinction was made between males and females in the sampling studies, and the sampling was done randomly.

Identifying fatty acids

Fatty acid analyses were performed in TÜBİTAK MAM according to IUPAC (1981) procedure in duplicate. Chromatographic separation was performed utilizing gas chromatography (GC, Perkin Elmer, Autosystem GLX, Shelton, USA), standard mix (Supelco 18919 F.A.M.E. Mix C4-C24). Fatty acids were defined according to the emergence time of the peaks given by the standards and the values determined as % area in the chromatograms were given as a result.

Identifying amino acids

The amino acid tests of the patterns were performed at TÜBİTAK MAM by Dimova (2003) and Gheshlaghi et al. (2008) reported the High-Performance Liquid Chromatography (HPLC) method was performed in duplicate. The procedure is based on extraction with phenyl isothiocyanate and acetonitrile: methanol: triethylamine solution after acidic hydrolysis is applied to break down the proteins in the sample into amino acid components and read in the UFLC-UV detector. Since tryptophan is entirely degraded as a consequence of acid hydrolysis, it was done by the base hydrolysis procedure. Sulfur-accommodating amino acids decompose right away meantime hydrolyzed with a strong acid solution, therefore they are not evaluated.

A total of 16 amino acids were examined. As a result of the analyses, the 16 amino acids, including methionine, phenylalanine, lysine, valine, leucine, isoleucine, threonine, arginine, histidine, alanine, aspartic acid, glutamic acid, tyrosine, glycine, serine, and proline were evaluated.

Statistical analysis

The data acquired from this research were exposed to analysis of variance (F Test) utilizing the SPSS 16.0 program. The means of the important resources of variance were matched with the Duncan Multiple Comparison Test, with an importance grade of P=0.05.

RESULTS

In our study, the average weight and length of bogue was 37.8±4.46g and 15.4±0.36 cm. It was noticed that seasonal changes in fatty acids obtained from the bogue samples taken regularly every month during the fishing season were usually important (P<0.05). According to results, palmitoleic acid and oleic acid from MUFAs, linoleic acid (except September), arachidonic acid, EPA, DPA, and DHA from PUFAs, C14:0, C16:0 and C18:0 from SFA (saturated fatty acid) were the dominant fatty acids in all months. Statistically insignificant changes (P>0.05) were observed between October-November and January-February for ΣSFA, between October-November and April for ΣMUFA, and between September-December and October-November for ΣPUFA. The highest ΣUNSFA value was observed in November, while the lowest one in December. Σω-3 PUFA, Σω-3 PUFA, Σ UNSFA, ΣUNSFA/ ΣSFA, EPA+DHA and ω-6/ω-3 values showed insignificant changes (P>0.05) between the November and December (Table 1).

The amino acid profile (EAA and NEAA) of bogue is presented in Table 2. There were significant monthly variations in the content of amino acids (P<0.05). While the highest methionine, phenylalanine, lysine, valine, leucine and isoleucine values were found in February, the highest histidine, alanine, threonine, tyrosine, glycine, serine, proline and ΣAA amounts were detected in February. Arginine, asparagine and glutamic acid reached their highest values in April. The lowest phenylalanine, valine, leucine, isoleucine, tyrosine, alanine, glycine, serine and proline values were obtained with April samples (Table 2).

DISCUSSION

Fatty acid values

The fatty acid compositions of bogue ranged from 23.92% to 37.33% SFAs, 17.48 - 36.57% MUFAs and 22.66 – 31.81% PUFAs. The highest fatty acids of bogue were palmitic acid (19.96%) (SFA), oleic acid (31.40%) (MUFA) and linoleic acid (18.39%) (PUFA).

The highest ΣPUFA/ΣSFA value was determined in October (1.32) and November (1.32), and the change of this value according to months was found to be insignificant (P>0.05) among themselves in October–November and January-February-March-April (Table 1).

The PUFA/SFA ratio is an important parameter for nutrition and a good criterion for determining the quality of fatty acids (Aberoumand and Baesi, 2023). The ΣPUFA/ΣSFA rate should be at least 0.45 as a consideration of the tendency of diet to affect the prevalence of coronary heart illness (HMSO,1994). This value of bogue was found above the recommended value in all months. It can be stated that bogue is a good food source in terms of ΣPUFA/ΣSFA. Similar results were obtained in Uçar (2020)'s study with the same species in Mersin Bay.

Table 1. Alterations in fatty acid component of *B. boops* (%)

Fatty acids	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
C6:0	0.06±0.0^{a}	0.00±0.00^{d}	0.00±0.00^{d}	0.02±0.00^{c}	0.00±0.00^{d}	0.04±0.00^{b}	0.01±0.10^{cd}	0.00±0.00^{d}
C8:0	0.06±0.01^{a}	0.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00^{b}
C10:0	0.11±0.05^{a}	0.00±0.00^{c}	0.00±0.00^{c}	0.00±0.00^{c}	0.00±0.00^{c}	0.08±0.00^{b}	0.00±0.00^{c}	0.00±0.00^{c}
C12:0	0.19±0.05^{a}	0.04±0.00^{a}	0.04±0.00^{a}	0.06±0.00^{a}	0.23±0.19^{a}	0.14±0.05^{a}	0.04±0.00^{a}	0.04±0.05^{a}
C13:0	0.08±0.00^{bc}	0.03±0.05^{d}	0.03±0.05^{d}	0.11±0.00^{a}	0.09±0.00^{b}	0.08±0.05^{c}	0.09±0.05^{bc}	0.03±0.00^{d}
C14:0	5.55±0.00^{a}	2.70±0.03^{f}	2.65±0.03^{f}	5.75±0.16±^{a}	4.79±0.02^{c}	5.17±0.11^{b}	4.32±0.10^{d}	3.61±0.01^{e}
C15:0	1.25±0.00^{b}	0.43±0.01^{f}	0.42±0.01^{f}	1.39±0.03^{a}	1.04±0.01^{d}	0.80±0.01^{e}	1.20±0.02^{c}	0.45±0.01^{f}
C16:0	19.96±0.05^{a}	15.15±0.07^{d}	15.19±0.06^{d}	17.10±0.35^{c}	16.86±0.03^{c}	18.16±0.25^{b}	18.08±0.21^{b}	15.26±0.07^{d}
C17:0	1.14±0.05^{a}	0.37±0.00^{d}	0.39±0.01^{d}	1.12±0.02^{a}	1.01±0.03^{b}	0.63±0.02^{c}	1.03±0.01^{b}	0.39±0.01^{d}
C18:0	7.86±0.00^{a}	4.50±0.04^{ef}	4.64±0.02^{e}	6.92±0.14^{b}	5.39±0.06^{d}	4.59±0.09^{ef}	6.70±0.65^{c}	4.40±0.03^{f}
C20:0	0.66±0.00^{c}	0.51±0.03^{e}	0.49±0.00^{e}	0.94±0.01^{a}	0.80±0.01^{b}	0.62±0.02^{d}	0.78±0.00^{b}	0.60±0.01^{d}
C21:0	0.11±0.0^{b}	0.00±0.00^{b}	0.00±0.00^{b}	0.22±0.01^{b}	0.58±0.57^{b}	1.05±1.05^{b}	0.62±0.01^{b}	2.65±0.02^{a}
C22:0	0.19±0.00^{c}	0.15±0.00^{d}	0.16±0.00^{d}	0.25±0.01^{a}	0.22±0.01^{b}	0.16±0.00^{d}	0.22±0.00^{b}	0.16±0.02^{d}
C23:0	0.05±0.01^{b}	0.00±0.00^{b}	0.00±0.00^{b}	0.28±0.00^{a}	0.12±0.09^{ab}	0.12±0.05^{ab}	0.03±0.01^{b}	0.17±0.13^{ab}
C24:0	0.09±0.05^{cd}	0.06±0.00^{e}	0.07±0.01^{e}	0.15±0.01^{b}	0.10±0.01^{c}	0.08±0.00^{d}	0.19±0.01^{a}	0.09±0.0^{cd}
ΣSFA	37.33±0.04^{a}	23.92±0.11^{e}	24.05±0.12^{e}	34.29±0.71^{b}	31.20±0.79^{c}	31.69±1.55^{c}	33.27±0.38^{bc}	27.82±0.26^{d}
C14:1	0.09±0.00^{a}	0.03±0.00^{a}	0.03±0.00^{a}	0.05±0.00^{a}	0.04±0.00^{a}	0.06±0.00^{a}	0.04±0.00^{a}	0.03±0.00^{a}
C15:1	0.04±0.03^{a}	0.00±0.00^{a}	0.03±0.03^{a}	0.02±0.01^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
C16:1	5.63±0.04^{a}	3.57±0.03^{e}	3.55±0.02^{e}	3.88±0.09^{d}	3.53±0.02^{e}	4.33±0.10^{b}	3.20±0.04^{f}	4.06±0.01^{c}
C18:1 ω-9*c*	11.40±0.03^{e}	30.33±0.24^{b}	30.22±0.13^{b}	11.80±0.25^{e}	16.90±0.03^{d}	19.69±0.40^{c}	11.80±0.12^{e}	31.40±0.14^{a}
C20:1	0.91±0.00^{e}	1.64±0.02^{a}	1.61±0.01^{a}	1.23±0.03^{c}	1.31±0.01^{b}	1.25±0.03^{c}	1.02±0.01^{d}	0.23±0.00^{f}
C22:1 ω-9	0.40±0.00^{d}	0.26±0.00^{e}	0.27±0.01^{e}	0.46±0.01^{b}	0.55±0.00^{a}	0.43±0.01^{c}	0.47±0.01^{b}	0.55±0.01^{a}
C24:1	0.62±0.05^{abc}	0.33±0.05^{c}	0.33±0.00^{c}	0.90±0.02^{ab}	0.74±0.00^{ab}	0.56±0.00^{bc}	0.97±0.01^{a}	0.30±0.29^{c}
ΣMUFA	19.07±0.04^{d}	36.15±0.29^{a}	36.03±0.13^{a}	18.32±0.38^{de}	23.07±0.02^{c}	26.30±0.52^{b}	17.48±0.17^{e}	36.57±0.13^{a}
C18:2 ω-6	0.98±0.07^{f}	18.39±0.09^{a}	18.26±0.09^{a}	2.58±0.07^{e}	6.63±0.01^{d}	8.85±0.19^{c}	2.69±0.03^{e}	12.45±0.04^{b}
C18:3 ω-6	0.13±0.01^{a}	0.11±0.00^{bcd}	0.11±0.00^{bcd}	0.10±0.01^{d}	0.12±0.01^{bc}	0.10±0.00^{cd}	0.05±0.00^{e}	0.13±0.01^{ab}
C18:3 ω-3	0.37±0.01^{c}	3.40±0.06^{a}	3.22±0.02^{a}	0.52±0.01^{bc}	0.96±0.19^{bc}	1.24±0.66^{b}	0.67±0.00^{bc}	0.42±0.01^{bc}
C20:2	0.99±0.00^{c}	1.21±0.01^{a}	1.21±0.01^{ab}	0.92±0.02^{d}	1.02±0.01^{c}	1.25±0.03^{a}	0.78±0.02^{e}	1.17±0.01^{b}
C20:3 ω-6	0.17±0.01^{b}	0.13±0.01^{d}	0.15±0.01^{c}	0.09±0.00^{a}	0.13±0.01^{d}	0.13±0.00^{d}	0.10±0.01^{a}	0.18±0.00^{a}
C20:3 ω-3	0.09±0.01^{c}	0.26±0.01^{ab}	0.25±0.00^{ab}	0.02±0.00^{c}	0.26±0.05^{ab}	0.20±0.00^{b}	0.31±0.01^{a}	0.22±0.07^{ab}
C20:4 ω-6	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}
C22:2	0.34±0.00^{c}	0.42±0.01^{b}	0.44±0.01^{a}	0.28±0.01^{d}	0.03±0.00^{e}	0.43±0.01^{ab}	0.01±0.00^{f}	0.03±0.00^{e}
C20:5 ω-3	5.45±0.01^{a}	2.19±0.01^{f}	2.37±0.02^{e}	3.77±0.04^{b}	3.41±0.04^{c}	3.70±0.08^{b}	3.25±0.04^{d}	2.04±0.01^{g}
C22:5 ω-3	2.01±0.02^{a}	0.86±0.02^{f}	0.98±0.01^{e}	1.76±0.03^{b}	1.59±0.01^{c}	1.30±0.03d	1.57±0.01c	1.28±0.01^{d}
C22:6 ω-3	12.09±0.01^{b}	4.28±0.05^{e}	4.35±0.02^{e}	12.40±0.24^{b}	10.70±0.01^{c}	9.27±0.14^{d}	16.36±0.10^{a}	4.26±0.00^{e}
ΣPUFA	25.59±0.06^{e}	31.68±0.12^{a}	31.81±0.16^{a}	25.24±0.46^{e}	26.55±0.20^{d}	27.51±0.19^{c}	28.45±0.18^{b}	22.66±0.02^{f}
TOTAL	81.99±0.14^{c}	91.75±0.52^{a}	91.88±0.40^{a}	77.85±1.55^{d}	80.81±0.58^{cd}	85.50±1.89^{b}	79.20±0.73^{cd}	87.05±0.15^{b}
Unidentified	18.01±0.14^{b}	8.26±0.52^{d}	8.12±0.40^{d}	22.16±1.55^{a}	19.20±0.58^{ab}	14.51±1.89^{c}	20.81±0.73^{ab}	12.96±0.15^{c}
ΣUNSFA	44.66±0.10^{ef}	67.83±0.41^{a}	67.84±0.29^{a}	43.56±0.84^{f}	49.61±0.21^{d}	53.81±0.34^{c}	45.93±0.35^{e}	59.23±0.11^{b}
ΣUNSFA/ ΣSFA	1.20±0.01^{f}	2.84±0.01^{a}	2.82±0.00^{a}	1.27±0.00^{f}	1.59±0.05^{d}	1.70±0.07^{c}	1.38±0.01^{e}	2.13±0.02^{b}
EPA+DHA	17.54±0.02^{b}	6.47±0.06^{f}	6.71±0.03^{f}	16.17±0.28^{c}	14.11±0.05^{d}	12.97±0.22^{e}	19.61±0.14^{a}	6.30±0.01^{f}
ω-3 PUFA	20.00±0.02^{b}	10.98±0.03^{f}	11.15±0.05^{f}	18.46±0.31^{c}	16.92±0.20^{d}	15.70±0.42^{e}	22.15±0.14^{a}	8.21±0.05^{g}
ω-6 PUFA	4.27±0.08^{f}	19.08±0.09^{a}	19.02±0.10^{a}	5.59±0.13^{e}	8.58±0.01^{d}	10.14±0.21^{c}	5.51±0.05^{e}	13.26±0.06^{b}
ω-6 / ω-3	0.21±0.01^{f}	1.74±0.01^{a}	1.71±0.01^{a}	0.30±0.00^{e}	0.51±0.01^{d}	0.65±0.03^{c}	0.25±0.00^{f}	1.62±0.02^{b}
ΣPUFA/ ΣSFA	0.69±0.01^{c}	1.32±0.01^{a}	1.32±0.00^{a}	0.74±0.01^{c}	0.85±0.03^{b}	0.87±0.05^{b}	0.85±0.01^{b}	0.81±0.01^{b}

In the same line, means with different lowercase letters are significantly different (P<0.05).

Table 2. Alterations in amino acid component of *B. boops* (mg/100g)

Amino acids	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Methionine	592.0±2.0c	534.0±1.0e	568.5±1.5d	592.0±1.0c	658.5±0.5b	688.0±3.0a	595.0±4.0c	563.0±3.0d
Phenylalanine	791.0±5.0c	735.5±2.5e	766.5±4.5d	786.0±1.0c	821.5±0.5b	913.0±7.0a	766.5±6.5d	666.0±7.0f
Lysine	3754.0±26.0c	2642.0±14.0g	3874.0±27.0b	3162.5±15.5e	3597.0±18.0d	4038.5±36.5a	3578.0±38.0d	3027.5±35.5f
Valine	1019,0±7.0c	1011.5±2.5c	972.0±4.0d	1027.5±4.5c	1074.0±6.0b	1126.5±8.5a	928.5±7.5e	877.0±9.0f
Leucine	1458.5±6.5d	1426.5±0.5e	1415.0±4.0e	1534.5±13.5c	1583.0±3.0b	1737.5±5.5a	1434.0±9.0de	1345.5±10.5f
Isoleucine	874.5±2.5c	856.0±1.0d	840.5±5.5e	908.5±1.5b	912.5±0.5b	1012.0±5.0a	820.5±2.5f	762.5±4.5g
Threonine	565.5±1.5c	565.5±1.5c	516.5±1.5d	496.5±0.5de	686.5±12.5a	614.5±2.5b	475.5±12.5e	496.5±3.5de
Arginine	597.5±3.5g	572.5±0.5h	819.0±0.0d	704.5±4.5f	888.0±7.0c	956.0±7.0b	775.5±13.5e	1089.5±12.0b
Histidine	618.0±2.0b	539.5±0.5d	569.0±3.0c	377.5±1.5f	648.0±13.0a	542.5±2.5d	444.5±0.5e	440.5±0.5e
Alanine	1096,0±4.0f	1248.5±0.5c	1062.5±2.5g	1203.5±0.5d	1332.5±1.5a	1304.5±5.5b	1113.0±7.0e	1052.5±7.5g
Asparagine	1497.5±8.5c	847.5±0.50e	1495.5±4.5c	1555.5±5.5b	1078.5±5.5d	717.0±2.0f	1500.5±12.5c	2004.0±16.0a
Glutamic acid	3343.0±10.0c	2924.0±2.0d	3341.0±2.0c	3640.5±11.5b	3379.0±3.0c	2481.5±15.5e	3344.0±5.0c	3705.0±28.0a
Tyrosine	663.0±4.0c	616.0±2.0f	646.0±4.0d	659.5±1.5cd	701.0±1.0b	748.0±6.0a	631.0±6.0e	582.5±6.5g
Glycine	1058.0±1.0f	1268.5±2.5b	1005.5±0.5g	1168.5±0.5d	1297.5±2.5a	1204.0±3.0c	1131.5±5.5e	925.5±3.5h
Serine	587.5±3.5b	521.0±0.0e	524.5±0.5e	508.0±6.0f	718.0±6.0a	556.0±2.0c	487.0±8.0g	537.5±3.5d
Proline	676.5±0.5f	770.0±1.0c	645.5±0.5g	751.0±0.0d	822.0±1.0a	814.0±2.0b	730.5±1.5e	615.0±4.0h
Total	19191.5±73.5bc	17078.5±17.5e	19061.5±61.5c	17076.0±16.0c	20197.5±34.5a	19462.5±113.5b	18755.5±124.5d	18689.5±154.5d

In the same line, means with different lowercase letters are significantly different (P<0.05).

Some researchers have studied the fatty acid contents of bogue (Kalogeropoulos et al., 2004; Özogul and Özogul, 2007; Diraman and Dibeklioglu, 2009; Zotos and Vouzanidou, 2011; Prato and Biandolino, 2012; Morales-Medina et al., 2015). Simat et al. (2015) studied the fatty acid amounts of bogue fish kept in natural and near fish cages. These researchers noticed that miristic acid, palmitic acid, stearic acid, palmitoleic acid, oleic acid, EPA and DHA as the dominant fatty acids. In our study, the highest PUFA value is different (Linoleic acid). In studies, conducted by Diraman and Dibeklioglu (2009) and Prato and Biandolino (2012), it was reported that the reason for the differences in fatty acid ratios could be habitat, feeding, age, size, reproductive status, environmental conditions, water temperature, gender, sexual maturity, salinity and season. Özogul and Özogul (2007) declerated that especially water temperature influences lipid content and fatty acid composition of fish muscle to a certain extend.

Fish is the only important source of PUFA for the human diet, especially ω-3 group (EPA and DHA) found in fish are very important for a healthy life and protection from diseases (cardiovascular diseases, colon cancer, immune system disorders) (Briggs et.al., 2017). It is stated by the United States that the total daily intake of ω-3 fatty acids is 1.6 g. Daily EPA + DHA intake is recommended as 0.5 g in infant feeding and 1 g in adults. The American Heart Association, also in the USA, recommends fish consumption as 340 g per week (Erkan, 2013). Ozogul et al. (2011) reported that adequate amounts of EPA and DHA should be taken for a healthy and regular diet. EPA+DHA as can be seen from the results of this study we conducted with bogue, it is understood that this species is a good source of DHA and EPA.

The proportions of ω-3 PUFAs (ranging from 8.21%-April to 22.15%-March) were higher than those of ω-6 PUFAs (ranging from 4.27% in Sep. to 19.08% in Oct.) (Table 1). The ω-6/ω-3 ratio is important for nutrition and 1/1-5/1 ratios are recommended for healthy food (Osman et al., 2001; Zuraini et al., 2006). Ozogul et al. (2011), stated that this ratio is a good indicator in determining the quality of fat, and it was reported by the British Ministry of Health that the ratio in the diet should be below 4 for the prevention of cardiovascular diseases (Zhang et al., 2020). It was decelerated by Moreira et al. (2001) that ω-3 PUFAs not only have a protective effect against diseases but also improve the nutritional value of food. In this study, the ratio of ω-6/ω-3 was found to range from 0.21 to 1.74 for bogue. These results are agree with previous studies and suitable ratios for healthy diets.

Cengiz et al. (2019) reported that the breeding time of fish varies depending on the environmental and ecological factors of their environment, and the breeding period of the bogue; according to different literature, they emphasized the period between January and July. In his study, he stated that the breeding period of the bogue, caught from Saros Gulf was between March and May. It can be seen in Table 1 that the DHA, Σ ω-3, ΣMUFA and EPA+DHA ratios are high during the breeding periods of this species. It was stated in a study that, fish require higher levels of PUFA, SFA and MUFA as energy sources in physiological processes such as egg production and spawning during reproductive periods (de Souza et al., 2020).

Amino acid values

In our study, the changes in amino acid values obtained from the bogue samples were detected as generally significant ($P<0.05$). Although their amounts vary monthly (between September and April), lysine, valine and leucine from the EAA, alanine, glysine, glutamic acid and aspartic acid values from the NEAA are seen to be the major amino acids in our study (Table 2). The highest value (4038.5mg/100g) belonged to lysine in February and the lowest one (440.5mg/100g) was histidin in April. The daily essential amino acid amounts needed for adults, teenagers, children and infants are given in the report published by the Food and Agriculture Organization (FAO, 2013). In this report, different values are given for each amino acid according to age limits. According to the report, with the amino acid averages obtained in our study, it is seen that the bogue can meet the required essential amino acid value significantly.

In a study conducted with *Upeneus moluccensis* (Bleeker, 1855), it was determined that the most essential amino acids were lysine and leucine, and non-essential amino acids were aspartic acid, glutamic acid, alanine and glycine. The same researchers stated that the amino acid content varies by month and that the spawning period and nutrition cause this change (Doğan and Ertan, 2017). Especially aspartic acid and glutamic acids are responsible for enzymatic reactions (Özçiçek and Erkan, 2018). Peng et al. (2013) stated that glutamic acid is an important amino acid in cell proliferation. In a study, the major amino acids of sea bream were found as glutamic acid, lysine and threonine, and the amounts of other amino acids are higher in sea bream (Zebel, 2021).

For the investigating the change in nutritional values of anchovy fish during migration, it was reported that glutamic acid, aspartic acid, lysine and leucine are dominant amino acids in all locations in anchovy fish caught in different locations in the Black Sea (Öğretmen, 2022). In a study conducted by Kendler et al. (2023), starry flounder is rich in lysine and leucine from EAA, aspartic acid and glutamic acid from NEAA in September, December and April.

There are numerous studies on the amino acid ingredient of seafood (Kim and Lall, 2000; Özyurt and Polat, 2006; Özden and Erkan, 2008; Adeyeye, 2009; Erkan et al., 2010; Oluwaniyi et al., 2010; Zhao et al., 2010; Özden and Erkan, 2011; Baki et al., 2015; Doğan and Ertan, 2017) and in these studies glutamic acid, aspartic acid, leucine and lysine were found the dominant amino acids. In these studies, it was emphasized that monthly or seasonal changes may be due to age, height, hunting region, spawning season and nutritional changes.

CONCLUSION

It was noticed that the fatty acids and amino acid contents of bogue samples showed monthly changes (between September and April), and these changes were generally important ($P<0.05$). So, this study revealed that bogue is a good food source in terms of fatty acids and amino acids, especially EAA and ω-3 fatty acids, which are among the basic nutritional components in the sampled period (fishing season).

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AUTHORSHIP CONTRIBUTION

This article was produced from the doctoral thesis of Hasan Cevher titled "Nutritional properties of bogue (*Boops boops* Linnaeus, 1758) fish". Hasan Cevher: Research, material preparation, writing. Şengül Bilgin: Research, writing, auditing. Güntekin Doğan: Writing-review.

CONFLICT OF INTEREST DECLARATION

The authors declare that there are no known financial or personal conflicts that could influence their research (article).

ETHICAL APPROVAL

No specific ethical approval was required for this study.

DATA AVAILABILITY

For questions regarding the datasets, the corresponding author should be contacted.

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