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The effects of age and individual size on the Fatty Acids and Elemental Composition of *Nemipterus randalli* Russell, 1986 from Mersin Bay, Turkey

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ABSTRACT

In this study, the effects of the age and individual size on total lipid content, fatty acids and elemental composition of *Nemipterus randalli* caught from the Mersin Bay were determined. The lipid content of all age groups was found at similar levels. However, the highest lipid level was determined in the 3+ age group (2.85%) while the lowest level was found in the 2+ age group (2.75%). Dominant fatty acids for each age group of *N. randalli* are palmitic acid (C16:0), stearic acid (C18:0), vaccenic acid (C18:1*n*7c), cetoleic acid (C22:1*n*11), eicosapentaenoic acid (EPA, C20:5*n*3), and docosahexaenoic acid (DHA, C22:6*n*3). The highest palmitic acid level was found in 3+ age group (20.45%) whereas the highest stearic acid level was found in the 2+ age group (15.00%). The highest vaccenic acid level was observed in the 3+ age group (6.47%) while the highest level of the cetoleic acid was observed in the 2+ age group (7.13%). The highest EPA and DHA were found to be 5.49% and 22.02% in the 1+ age group. Macro elements (Na, Mg, P, K), trace elements (Cu, Zn, Fe) and potentially toxic metals (Cd, Cr, Pb, As) were investigated in muscle tissue and the levels of Cr, Cu, Cd and Pb were not evaluated since their levels were below the detection limit of the device (ICP-MS). Element level of muscle tissue changed according to different age groups as K>P>Na>Mg>Ca>Fe>As>Zn, respectively.

Keywords: Mersin Bay, *Nemipterus randalli*, Age, Lipid, Fatty acids, Elemental Composition

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1. Introduction

The biochemical composition of the fish varies depending on the water temperature, the biological and developmental status of the fish such as gender, length, age and maturity status, nutrition and reproduction. The main components of the fish are water, fat, TMS (total mineral substance) and protein (Turan et al., 2006). Fish are an important source of nutrients for people because of high levels of their proteins which have high biological value, their fatty acids, high levels of their minerals and vitamins. The flavor of fish is closely related to the protein and lipid content, and the variation of these components in fish is one of the main factors affecting consumer preference (Kuzu, 2005). Interest in fish which composition has been increasing in recent years due to fatty acid, especially after the omega-3 fatty acids have been found to be beneficial in some important disorders such as depression, hypertension, cancer.

One of the basic components of seafood is marine lipids. Marine lipids are one of the important ingredients for human nutrition. The most common vitamins in fish are thiamine (B1), riboflavin (B2), pyridoxine (B6), niacin (B3) and cobalamin (B12) from water soluble B group vitamins and vitamin D and vitamin E. Lipid-soluble vitamins are stored especially in liver oil. Fish do not contain carbohydrates like other meats; for this reason, the energy of the fish is caused by the lipid and protein contents. The energy values of fish vary according to the amount of lipid in their composition; the energy values of oily fish are higher than those of lean fish. Fish and other seafood have a distinctive pattern of healthy nutrition in terms of their rich mineral content. Minerals such as iodine and selenium are found in large quantities in fish and other seafood. In addition, among abundant minerals in fish, phosphorus, magnesium and zinc are present and consumption of fish is important in meeting the daily needs of these minerals (Baysal, 2004; Kaya et al., 2004; Kayahan, 2005; Kesler, 1994).

The Suez Canal, which opened in 1869 to shorten trade routes between the Mediterranean Sea and the Indian Ocean, lifted the geographical obstacles between the Red Sea and the Mediterranean Sea, thus initiating a migration from the Red Sea to the Mediterranean Sea and, occasionally, the reverse. The species that passed from the Red Sea to the Mediterranean Sea were named by DovPor in 1978 as lessepsian species.

Nemipterus randallii is commonly found along the Seychelles and Madagascar in the Western Indian Ocean region, between the Indian, Pakistani, Persian Gulf, and Gulf of Aden, East African borders covering the eastern and western coasts. Since 2006, the Mediterranean Sea has been added to this geographical distribution region. *N. randalli* was mistakenly identified as *N. japonicus* by Golani and Sonin (2006). Two years later, Lelli et al. (2008) reported from Lebanese seafarers. *N. randalli* was recorded by Bilecenoglu and Russell (2008) in Turkey coastal waters for the first time in the Gulf of Iskenderun. The first report for the Aegean Sea, Turkey was reported by Gülşahin and Kara (2013).

A small number of studies which is related to this species which has a large population in the Mediterranean Sea and Turkish coastal waters have been found in the literature. In this study, it was aimed to determine the total lipid level of *N. randalli* (Russell, 1986), a Lessepsian fish species which is a commercial prevalence in our country, and the changes of the composition of element and fatty acid in terms of age groups.

2. Materials and Methods

N. randalli individuals were obtained from the Mersin Bay in December 2016 from the trawler (Figure 1). 15 individuals from each age group were sampled and the study was conducted with 45 individuals. In the determination of age groups, the study which was conducted based on the length-age relationship of the *N. randalli* by Erguden et al. (2010) was used. Controls of age groups were confirmed by examining the sagittal otoliths. In determining the age of fish, only the largest of three pairs of otoliths on either side of the head, the sagittal otoliths, were used. To get otolith, the bones in the head were cut with a sharp knife and crushed, and a pens were used to find otolith. Age of *N. randalli* specimens were calculated by reading of the sagittal otoliths. Before otolith reading, they were carefully removed and then were cleaned with

4% NAOH and stayed in 70% ethyl alcohol, and then placed in boiling distilled water for 5-6 minutes. Every opaque ring on the sagittal otolith as an annuli were determined with using a stereo microscope (Farrag et al., 2015).

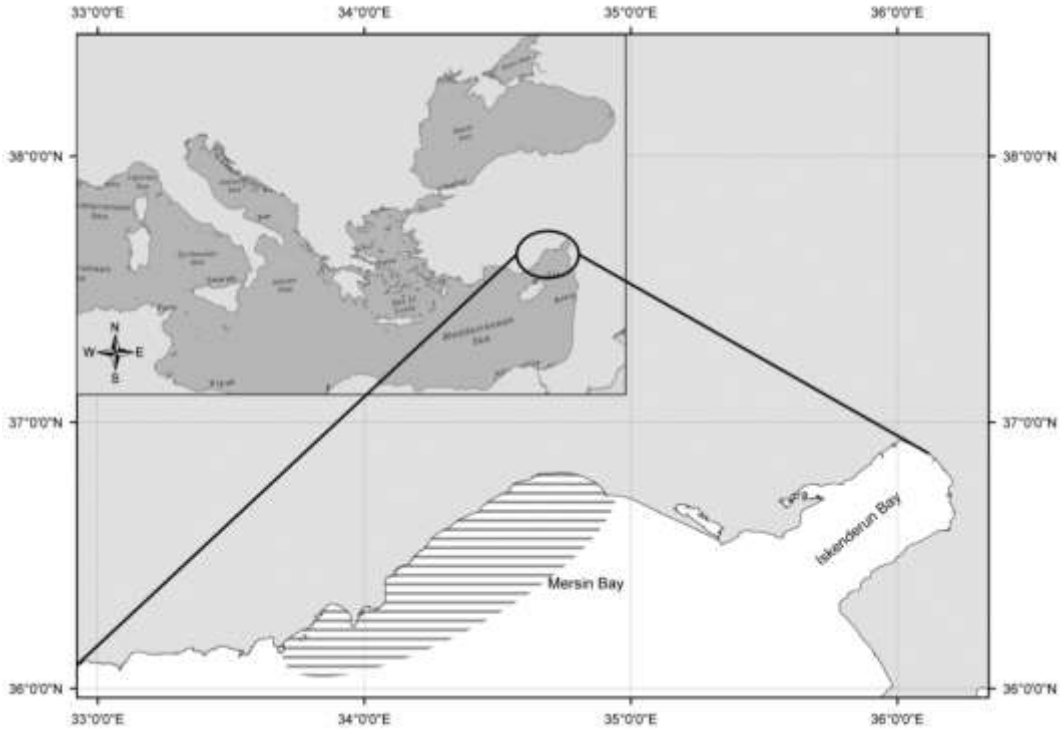

Figure 1: Sampling location map. (The shaded region (Mersin Bay) is the sampling area)

The weight and size of all age groups (1+ - 3+) were measured and given in Table 1. While the lengths of fish were measured between 15 cm and 19.5 cm, the weights were measured between 46 g and 103 g (Table 1).

Table 1. Length and weight at age groups of *N. randalli*

Ages	N	Mean TL (cm) $\bar{X} \pm S_x$	Mean Weight (g) $\bar{X} \pm S_x$
0+	0	0	0
1+	15	15.29±0.22[a]	51.80±4.62[a]
2+	15	17.13±0.51[b]	68.33±2.13[b]
3+	15	19.07±0.43[c]	97.33±4.17[c]

The values on the same column, shown in different letters, are statistically different ($p<0.05$)
TL: total length, W: weight $\bar{X} \pm S_x$: mean±Standart deviation

Fat and Fatty Acids Analyses

Lipid analysis was performed using Bligh & Dyer (1959) method. In extracted lipids, fatty acid methyl esters were obtained using the Ichibara et al. (1996) method. Fatty acid composition was analyzed using a Gas Chromatography (GC) Clarus 500 device (Perkin–Elmer, USA), one flame ionization detector (FID) and SGE (60 m x 0.32 mm ID BPX70 x 0.25 µm, USA or Australia) column.

Injector and detector temperatures were set as 260 ^{o}C and 230 ^{o}C respectively. During this time, the furnace temperature was kept at 140 ^{o}C for 8 minutes. After that, it was increased by 4 ^{o}C per minute until 220 ^{o}C, and from 220 ^{o}C to 230 ^{o}C by increasing the temperature 1^{o}C per minute. It was kept at 230 ^{o}C for 15 minutes to complete analysis. Sample scale was 1 µl and carrier gas was controlled at 16 ps. The split used was 1:50. Fatty acids were identified by comparing the retention times of FAME with a standard 37-component fatty acid methyl ester mixture (catalog no 18919; Supelco).

Conversion factor

Triplicate GC analyses were performed and the results were converted to mg fatty acid per 100 g total lipid using lipid conversion factors and then to mg fatty acid per 100 g edible portion of food using the total lipid content. Details of the derivation of lipid conversion factors were published by Weihrauch et al. (1975).

Factor (Fish) = 0.956-0.143/total lipid
Fatty acid (mg/100g) = Factor x FAME (%) x lipid level (%) x 10

Atherogenicity index (AI) and thrombogenicity index (TI)

The AI and TI linked to the fatty acid composition were calculated according to Ulbricht and Southgate (1991).

AI = [(a*C12:0)+(b*C14:0)+(c*C16:0)] / [d*(PUFA n-6+n-3)+e*(MUFA)+f*(MUFA-C18:1)]

TI = [g*(C14:0+C16:0+(C18:0)] / [(h*MUFA)+i*(MUFA-C18:1)+(m*n-6)+(n*n-3)+(n-3/n-6)]

a, c, d, e, f=1; b=4; g=1; h, i, m=0.5; n=3

Metal analysis

The samples (0.1 g dry weight) used for metal analysis were dried at 105°C to reach constant weights, and then concentrated nitric acid (2 mL, Merck, Darmstadt, Germany) and percholoric acid (1 mL, Merck, Darmstadt, Germany) were added to the samples, and they were put on a hot plate set to 150°C until all tissues were dissolved (Canli and Atli, 2003).

Inductively coupled plasma mass spectrometer (ICP-MS, Agilent, 7500ce Model, Japan) was used to determine metals. ICP-MS operating conditions were the following: radio frequency (RF) (W),1500; plasma gas flow rate (L min-1),15; auxiliary gas flow rate (L min-1), 1; carrier gas flow rate (L min-1),1.1; spray chamber T (°C),2; sample depth (mm),8,6; sample introduction flow rate (mL min-1),1; nebuliser pump (rps),0.1; extract lens (V),1.5. All digested samples were analyzed three times for each metals. All chemicals and standard solutions used in the study were obtained from Merck and were of analytical grade. Macro elements (Na, Mg, P, K, Ca), trace elements (Cu, Zn, Fe) and potentially toxic metals (Cd, Cr, Pb, As) were investigated in muscle tissue. The levels of Cr, Cu, Cd and Pb were not evaluated which their levels were below the detection limit of the device. The levels of elements (Na, Mg, P, K, Ca, Fe, Zn, As) in samples were detected as µg metal g^{-1} dry weight. High Purity Multi Standard (Charleston, SC 29423) was used for determination of the metal analyses. Standard solutions for calibration curves were prepared by dilutions of the potential toxic metals. Solutions prepared for the toxic metal had a content of arsenic in the range of 1-50 ppb (0.001 to 0.050 mg/L).

Statistical analysis

Prior to the analyses, all data were checked for outliers and homogeneity of variance was also tested. Statistical analysis of data was carried out with the IBM SPSS STATISTICS 22 statistical program. ANOVA (Analysis of Variance) was used to evaluate the effect of age on the metals levels.

3. Results

Table 2. Lipid levels of different age groups of *N. randalli* (%)

	1+ $\bar{X}\pm S_{\bar{x}}$	2+ $\bar{X}\pm S_{\bar{x}}$	3+ $\bar{X}\pm S_{\bar{x}}$
% lipid	2.79±0.09[a]	2.75±0.08[a]	2.85±0.07[a]

The values on the same line, shown in different letters, are statistically different ($p<0.05$). $\bar{X}\pm S_{\bar{x}}$: mean±Standart deviation

There was no statistical difference among the age groups ($p<0.05$). The lipid levels of different age groups of *N. randalli* varied between 2.75% and 2.85%. The highest lipid value was found to be 2.85% in the 3+ age group and the lowest value was found in the 2+ age group as 2.75% (Table 1).

Fatty acid Levels (%)

The main fatty acids of *N. randalli* are lauric acid (C12:0), myristic acid (C14:0), pentadecanoic acid (C15:0), palmitic acid (C16:0), heptadecanoic acid (C17:0), stearic acid (C18:0), arachidic acid (C20:0), trichosanoic acid (C23:0), lignoceric acid (C24:0), palmitoleic acid (C16:1), heptadecenoic acid (C17:1), elaidic acid (C18:1*n*9t), vaccenic acid (C18:1*n*7), oleic acid (C18:1*n*9), gadoleic acid (C20:1*n*9), cetoleic acid (C22:1*n*11), nervonic acid (C24:1*n*9), linoleic acid (C18:2*n*6), gamma linolenic acid (C18:3*n*6), eicosatrienoic acid (C20:3*n*6), eicosatrienoic acid (C20:3*n*3), arachidonic acid (C20:4*n*6), eicosapentaenoic acid (C20:5*n*3), docosadienoic acid (C22:2cis) and docosahexaenoic acid (C22:6*n*3) (Table 3, 4).

Table 3. Fatty acids profiles of different age groups of *N. randalli* (%)

Fatty acid (%)	**1+** $\bar{X}\pm S_{\bar{x}}$	**2+** $\bar{X}\pm S_{\bar{x}}$	**3+** $\bar{X}\pm S_{\bar{x}}$
lauric acid (C12:0)	0.24±0.01[a]	0.38±0.04[c]	0.30±0.02[b]
myristic acid (C14:0)	0.88±0.05[b]	0.44±0.10[a]	0.77±0.03[b]
pentadecanoic acid (C15:0)	0.49±0.03[b]	0.37±0.02[a]	0.48±0.01[b]
palmitic acid (C16:0)	18.20±0.68[b]	14.86±0.52[a]	20.45±0.42[c]
heptadecanoic acid (C17:0)	0.87±0.01[b]	0.80±0.01[a]	0.88±0.01[b]
stearic acid (C18:0)	12.12±0.81[a]	15.00±0.30[c]	13.33±0.49[b]
arachidic acid (C20:0)	0.35±0.02[a]	0.33±0.01[a]	0.36±0.02[a]
trichosanoic acid (C23:0)	2.43±0.10[a]	2.99±0.10[b]	2.71±0.02[c]
lignoceric acid (C24:0)	2.44±0.11[a]	3.05±0.18[c]	2.73±0.03[b]
∑SFA	**38.02**	**38.22**	**42.01**
palmitoleic acid (C16:1)	1.80±0.03[b]	1.32±0.15[a]	1.75±0.08[b]
heptadecenoic acid (C17:1)	0.34±0.01[a]	0.34±0.04[a]	0.29±0.10[a]
elaidic acid (C18:1*n*9t)	0.19±0.02[a]	ND	ND
vaccenic acid (C18:1*n*7c)	5.20±0.10[a]	5.20±0.42[a]	6.47±0.28[b]
oleic acid (C18:1*n*9)	1.62±0.05[b]	1.49±0.06[a]	1.96±0.07[c]
gadoleic acid (C20:1*n*9)	0.45±0.02[b]	0.29±0.02[a]	0.46±0.02[b]
cetoleic acid (C22:1*n*11)	6.79±0.03[ab]	7.13±0.47[b]	6.25±0.11[a]
nervonic acid (C24:1*n*9)	0.18±0.02[a]	0.18±0.01[a]	0.17±0.03[a]
∑MUFA	**16.57**	**15.95**	**17.35**
linoleic acid (C18:2*n*6)	1.30±0.02[a]	1.30±0.04[a]	1.31±0.03[a]
gamma linolenic acid (C18:3*n*6)	0.16±0.02[a]	0.19±0.00[b]	0.19±0.01[b]
eicosatrienoic acid (C20:3*n*6)	0.22±0.01[b]	0.20±0.01[a]	0.21±0.01[ab]
eicosatrienoic acid (C20:3*n*3)	0.18±0.01[a]	0.23±0.02[b]	0.24±0.02[b]

arachidonic acid (C20:4*n*6)	0.29±0.01[a]	0.30±0.01[a]	0.33±0.01[b]
eicosapentaenoic acid (C20:5*n*3)	5.49±0.16[b]	3.75±0.25[a]	3.78±0.03[a]
docosadienoic acid (C22:2cis)	0.47±0.01[c]	0.43±0.01[b]	0.14±0.10[a]
docosahexaenoic acid (C22:6*n*3)	22.02±0.78[b]	20.16±0.60[a]	21.44±0.18[b]
∑PUFA	**30.13**	**26.56**	**27.64**
SFA/PUFA	1.26	1.44	1.52
∑*n*6	1.97	1.99	2.04
∑*n*3	27.69	24.14	25.46
***n*6/*n*3**	0.07	0.08	0.08
***n*3/*n*6**	14.06	12.13	12.48
DHA/EPA	4.01	5.38	5.67
AI	0.48	0.40	0.53
TI	0.29	0.32	0.47
Unidentified	**15.28**	**19.27**	**13.00**

Uppercases in same lines indicates difference ($p<0.05$). $\bar{X} \pm S_{\bar{x}}$: Average±Standard deviation

N. randalli's dominant SFAs (saturated fatty acids) are palmitic acid and stearic acid, MUFAs (mono unsaturated fatty acids) are vaccenic acid and cetoleic acid, PUFAs (poly unsaturated fatty acids) are EPA and DHA fatty acids (Table 3).

ΣSFA, ΣMUFA, and ΣPUFA levels are calculated to be 38.02-42.01%, 15.95-17.35%, 26.56-30.13%, respectively. ΣSFA for the 1+, 2+ and 3+ age groups were 38.02%, 38.22% and 42.01%, respectively. The highest value of ΣSFA was determined in the 3+ age group with 42.01%, while the lowest value was found in the 1+ age group with 38.02%. ΣMUFA values were determined as 16.57%, 15.95%, and 17.35% for the 1+, 2+ and 3+ age groups, respectively. The highest ΣMUFA level was also calculated for the 3+ age group with 17.35%, while the lowest level was found in the 2+ age group with 15.95%. The ΣPUFA levels in the 1+, 2+ and 3+ age groups were determined as 30.13%, 26.56% and 27.64% respectively. The highest ΣPUFA level (30.13%) was detected in the 1+ age group while the lowest (26.56%) was found in the 2+ age group.

A statistical difference was found between the lauric acid levels of different age groups ($p<0.05$). While the lowest level was found in 1+ age group (0.24%), the highest level was found in 2+ age group (0.38%). There is a statistically significant difference between the 2+ age group and the other 2 age group for miristic acid and pentadecanoic acid levels ($p<0.05$). The level of myristic acid also varied from 0.44% to 0.88%. Pentadecanoic acid level was highest in 1+ age group (0.49%) and lowest in 2+ age group (0.37%). There is a statistically significant difference between palmitic acid levels of different age groups of *N. randalli* ($p<0.05$). Palmitic acid was the highest (20.45%) in the 3+ age group, while the lowest (14.86%) was in the 2+ age group. The palmitic acid levels of 1+, 2+ and 3+ age groups were determined as 18.20%, 14.86% and 20.45%, respectively. There was statistically significant difference between heptadecanoic acid level in 2+ age group and other 2 age group ($p<0.05$). The levels of this fatty acid were determined in the range of 0.80-0.88%. Stearic acid levels were determined as 12.12%, 15.00% and 13.33% for 1+, 2+ and 3+ age groups, respectively. There was a statistically significant difference between the stearic acid levels of the age groups ($p<0.05$). Stearic acid level reached the highest level (15.00%) in 2+ age group. The lowest value (12.12%) was found in the 1+ age group. Arachidic acid levels vary between 0.33-0.36%. There was no statistically significant difference between the age groups in terms of arachidic acid levels ($p>0.05$). There was a statistically significant difference between the age groups in terms of trichosanoic acid and lignoceric acid levels ($p<0.05$). Tricosanoic acid levels vary between 2.43-2.99% and lignoceric acid levels vary between 2.44-3.05%.

The values vaccenic acid of ranged from 5.20 to 6.47%, while that of oleic acid (C18:1*n*9) varied from 1.49 to 1.96%. The vaccenic acid levels of 1+, 2+ and 3+ age groups were determined as 5.20%, 5.20%, and 6.47% respectively. There was no statistically significant difference between levels of

1+ and 2+ age groups (p>0.05). There was statistically significant difference between 3+ age group and 1+ and 2+ age groups for the vaccenic acid (p<0.05). While the highest vaccenic acid (6.47%) was detected in the 3+ age group, the vaccenic acid levels of 1+ and 2+ age groups were found to be the same. The oleic acid levels of the 1+, 2+ and 3+ age groups were 1.62%, 1.49% and 1.96%, respectively. There was a statistically significant difference among the levels of 1+, 2+, and 3+ age groups (p<0.05). The lowest value in oleic acid level was obtained in the 2+ age group (1.49%) and the highest level (1.96%) in the 3+ age group. Palmitoleic acid levels differed between the 2+ age group and the other 2 age group (p<0.05). The highest value was found in the 1+ age group (1.80%) and the lowest value in the 2+ age group (1.32%). There was no difference in heptadecenoic acid level between the age groups (p>0.05). The highest value of this fatty acid was in the 1+ and 2+ age groups (0.34%) and the lowest value was in the 3+ age group (0.29%). Elaidic acid level was found to be 0.19% for 1+ age group and below detection limit for the other two age groups. There was a statistically significant difference between the levels of gadoleic acid of the 1+ and 3+ age groups and 2+ age group (p<0.05). The low level of this fatty acid was found in the 2+ age group (0.29%) while the high level was found in the 3+ age group (0.46%). There was a statistically significant difference among the age groups of cetoleic acid (p<0.05). The lowest level was found in 3+ age group (6.25%) while the highest level was found in 2+ age group (7.13%). No statistically significant difference was found among the age groups at nervonic acid level (p>0.05). The highest level of this fatty acid was detected in the 1+ and 2+ age groups (0.18%).

Linoleic acid level was the highest in 3+ age group (1.31%) and the lowest in 1+ and 2+ age group (1.30%). There was no statistically significant difference among the linoleic acid levels of 1+, 2+ and 3+ age groups (p>0.05). There was a statistically significant difference between the 1+ age group and the other 2 age groups of gamma-linolenic acid level (p<0.05). The lowest gamma-linolenic acid level was detected in 1+ age group (0.16%) while the highest value was found in 2+ and 3+ age group (0.19%). There was a statistically significant difference between the 3+ age group and the other 2 age group of arachidonic acid level (p<0.05). The arachidonic acid levels of 1+, 2+ and 3+ age groups were very close to each other and were determined as 0.29%, 0.30% and 0.33%, respectively. There was a statistically significant difference among the docosadienoic acid levels of the age groups (p<0.05). This fatty acid showed a change in the range of 0.14-0.47%. There was a statistically significant difference among the levels of eicosatrienoic acid (C20:3*n*6) (p<0.05). This fatty acid was found in the highest 1+ age group (0.22%) and the lowest in the 2+ age group (0.20%). Eicosatrienoic acid (C20:3*n*3) level was statistically different between 1+ age group and other 2 age group (p<0.05). This change in fatty acid level varied between 0.18-0.23%. While the EPA levels among the age groups varied between 3.75% and 5.49%, the DHA acid level varied between 20.16-22.02%. For EPA and DHA fatty acids were found to reach the highest levels in 1+ age group. There was no statistical difference in 2+ and 3+ age groups for EPA levels (p>0.05). There was a statistically significant difference between the 1+ age group and the other 2 age group (p<0.05). EPA fatty acid levels of 1+, 2+ and 3+ age groups were 5.49%, 3.75% and 3.78%, respectively. The lowest level of DHA fatty acid was found in 2+ and the highest level in 1+ age group. There was no statistical difference between DHA fatty acid levels of 1+ and 3+ age groups (p>0.05). There was a statistical difference between the 2+ age group and the other 2 age group (p<0.05). DHA fatty acid levels of 1+, 2+ and 3+ age groups were determined as 22.02%, 20.16% and 21.44% respectively.

The values of ∑SFA/∑PUFA, DHA/EPA, *n*6/*n*3, *n*3/*n*6, AI (Atherogenicity Index) and TI (Thrombogenicity Index) were calculated. The differences of the indices of the relationship between the fatty acid composition and the human nutrition were determined in the all age groups.

The range of *n*3/*n*6, *n*6/*n*3, Σ*n*3, and Σ*n*6 were 12.13-14.06%, 0.07-0.08%, 24.14-27.00% 1.97-2.04%, respectively. The *n*3/*n*6 level was the highest in the 1+ age group and the lowest in the 2+ age group. *n*6/*n*3 level was found to be 0.08% for 2+ and 3+ age groups, while for 1+ age group it was found to be 0.07%. The highest level of Σ*n*3 was in

the 1+ age group, while the lowest was in the 2+ age group. The highest level of Σ*n*6 was 3+ and the lowest level of age group was 1 + age group. The UK health ministry has reported that the *n*6/*n*3 ratio in seafood should be a maximum of 4% (HSMO 1994). Our findings are lower than this value.

Calculations were performed using C12:0, C14:0 and C16:0, MUFA and PUFA values for the Atherogenicity index, and C14:0, C16:0 and C18:0, MUFA and PUFA values for the Thrombogenicity Index. The AI index is calculated in the range of 0.40-0.53% while the TI index is calculated as 0.29-0.47%. These index ratios indicate a high level of compliance with cardiovascular diseases.

Fatty acid Levels (mg/100g)

The changes in fatty acid levels of *N. randalli* according to different age groups are given in Table 4 as mg/100g.

Table 4. Fatty acids profiles of different age groups of *N. randalli* (mg/100g)

Lipid %	**2.79**	**2.75**	**2.85**
Coversion factor	**0.882**	**0.881**	**0.883**
Fatty acid	**1+**	**2+**	**3+**
lauric acid (C12:0)	5.91	9.21	7.55
myristic acid (C14:0)	21.65	10.66	19.38
pentadecanoic acid (C15:0)	12.06	8.96	12.08
palmitic acid (C16:0)	447.86	360.02	514.63
heptadecanoic acid (C17:0)	21.41	19.38	22.15
stearic acid (C18:0)	298.25	363.41	335.46
arachidic acid (C20:0)	8.61	7.99	9.06
trichosanoic acid (C23:0)	59.80	72.44	68.20
lignoceric acid (C24:0)	60.04	73.89	68.70
ΣSFA	**935.59**	**925.98**	**1057.20**
palmitoleic acid (C16:1)	44.29	31.98	44.04
heptadecenoic acid (C17:1)	8.37	8.24	7.30
elaidic acid (C18:1*n*9t)	4.68	ND	ND
vaccenic acid (C18:1*n*7)	127.96	125.98	162.82
oleic acid (C18:1*n*9)	39.86	36.10	49.32
gadoleic acid (C20:1*n*9)	11.07	7.03	11.58
cetoleic acid (C22:1*n*11)	167.09	172.74	157.28
nervonic acid (C24:1*n*9)	4.43	4.36	4.28
ΣMUFA	**407.75**	**386.43**	**436.62**
linoleic acid (C18:2*n*6)	31.99	31.50	32.97
gamma linolenic acid (C18:3*n*6)	3.94	4.60	4.78
eicosatrienoic acid (C20:3*n*6)	5.41	4.85	5.28
eicosatrienoic acid (C20:3*n*3)	4.43	5.57	6.04
arachidonic acid (C20:4*n*6)	7.14	7.27	8.30
eicosapentaenoic acid (C20:5*n*3)	135.10	90.85	95.13
docosadienoic acid (C22:2cis)	11.57	10.42	3.52
docosahexaenoic acid (C22:6*n*3)	541.86	488.43	539.55
ΣPUFA	**741.43**	**643.48**	**695.57**
SFA/PUFA	31.01	34.89	38.25
Σ*n*6	48.48	48.21	51.34
Σ*n*3	681.39	584.85	640.71
***n*6/*n*3**	1.72	1.94	2.01
***n*3/*n*6**	345.99	293.88	314.07
DHA/EPA	98.68	130.34	142.69
AI	11.81	9.69	13.34
TI	7.14	7.75	11.83
Unidentified	376.01	466.86	327.15

The ranges of the ∑SFAs, ∑MUFAs and ∑PUFAs of *N. randalli* according to age groups were 925.98-1057.20 mg/100g, 386.43-436.62 mg/100g, and 643.48-741.43 mg/100g. ∑SFAs were determined as 935.59 mg/100g, 925.98 mg/100g and 1057.20 mg/100g for the 1+, 2+ and 3+ age groups, respectively. Lauric acid was detected in the lowest 1+ age group (5.91 mg/100g) and the highest value in the 2+ age group (9.21 mg/100g). The levels of myristic acid 1+, 2+ and 3+ age groups were 21.65 mg/100g, 10.66 mg/100g and 19.38 mg/100g respectively. Pentadecanoic acid levels were highest in the 3+ age group (12.08 mg/100g) and lowest in the 2+ age group (8.96 mg/100g). The palmitic acid levels of 1+, 2+ and 3+ age groups were calculated as 447.86 mg/100g, 360.02 mg/100g and 514.63 mg/100g respectively, while for stearic acid levels were 298.25 mg/100g, 363.41 mg/100g and 335.46 mg/100g, respectively. The highest level of palmitic acid was detected in 3+ age group while the lowest level was found in 2+ age group. Stearic acid was highest level in the 2+ age group and lowest in the 1+ age group. Arachidic acid levels were highest in the 3+ age group (9.06 mg/100g) and lowest in the 2+ age group (7.99 mg/100g). Tricosanoic acid and lignoceric acid levels were highest in the 2+ age group and lowest in the 1+ age group.

∑MUFAs values were determined as 407.75 mg/100g, 386.43 mg/100g, and 436.62 mg/100g for the 1+, 2+ and 3+ age groups, respectively. The palmitoleic acid levels of the 1+, 2+ and 3+ age groups were 44.29 mg/100g, 31.98 mg/100g and 44.04 mg/100 g respectively. Heptadecanoic acid was the highest level in the 1+ age group (8.37 mg/100g), while the lowest level was found in the 3+ age group (7.30 mg/100g). Elaidic acid level is below the detection limit for 2+ and 3+ age groups. Vaccenic acid and oleic acid are the highest levels in the 3+ age group. The levels of vaccenic acid obtained for the 1+, 2+ and 3+ age groups were determined as 127.96 mg/100g, 125.98 mg/100g and 162.82 mg/100g, respectively and the levels of oleic acid were 39.86 mg/100 g, 36.10 mg/100 g and 49.32 mg/100 g, respectively. Gadoleic acid were highest level in the 3+ age group (11.58 mg/100g) and the lowest in the 2+ age group (7.03 mg/100g). The levels of cetoleic acid were determined as 167.09 mg/100g, 172.74 mg/100g and 157.28 mg/100g according to 1+, 2+ and 3+ age groups, respectively. The highest level of nervonic acid was found in 1+ age group.

∑PUFAs levels of 1+, 2+ and 3+ age groups were determined as 741.43 mg/100g, 643.48 mg/100g, and 695.57 mg/100g, respectively. The ranges of linoleic acid, gamma-linolenic acid, arachidonic acid, EPA and DHA were found to be 31.50-32.97 mg/100g, 3.94-4.78 mg/100g, 7.14-8.30 mg/100 g, 90.85-135.10 mg/100 g, and 488.43-541.86 mg/100 g. The highest age group of these fatty acids was found to be 3+ age group for linoleic acid, gamma-linolenic acid and arachidonic acid, while was found to be 1+ age group for EPA and DHA.

Element levels

The changes of the element levels in muscle tissue according to age groups are given in Table 5. The levels of Cr, Cu, Cd and Pb were not calculated because they were below the detection value of the device (Table 5). The levels of the elements in muscle tissue changed from big to small as K> P> Na> Mg> Ca> Fe> As> Zn, respectively.

Table 5. Elemental profiles of different age groups of *N. randalli* (μg g^{-1} dw).

Elements	1+ $\bar{X}\pm S_{\bar{x}}$	2+ $\bar{X}\pm S_{\bar{x}}$	3+ $\bar{X}\pm S_{\bar{x}}$
Na	2685.1±256.22[a]	4959.7±588.96[b]	7758.8±1094.18[c]
Mg	974.25±40.71[a]	1146.9±52.87[a]	1539.8±139.99[b]
P	11492.0±299.64[a]	11362.0±428.70[a]	11283.0±496.11[a]
K	24557.0±1790.90[b]	21342.0±1036.13[ab]	19567.0±767.36[a]
Ca	348.55±22.01[a]	725.52±115.35[b]	1194.7±195.11[c]

Cr	ND	ND	ND
Fe	27.63±2.17[a]	41.73±6.36[b]	53.36±5.62[b]
Cu	ND	ND	ND
Zn	8.37±0.31[a]	10.36±1.57[a]	9.19±1.07[a]
As	44.55±4.38[b]	39.53±4.25[b]	27.50±1.56[a]
Cd	ND	ND	ND
Pb	ND	ND	ND

Uppercases in same lines indicates difference ($p<0.05$). $\overline{X} \pm S_{\overline{X}}$: Average±Standard error. The unit of element levels (µg g^{-1}dw) ND: not detected.

Na level of the muscle tissue was found to be 2685.1 µg g^{-1}dw for 1+ age group, 4959.7 µg g^{-1}dw for 2+ age group and 7758.8 µg g^{-1}dw for 3+ age group. They changed from big to small as 3+, 2+ and 1+ age groups, respectively. There also was a statistically significant difference among the age groups ($p<0.05$).

The Mg levels in the muscle tissue was determined as 974.3 µg g^{-1}dw for 1+ age group, 1146.9 µg g^{-1}dw for 2+ age group and 1539.8 µg g^{-1}dw for 3+ age group. According to the results, the lowest level of Mg was found in 1+ age group and the highest level in 3+ age group. Mg level changed according to age groups as 3+, 2+ and 1+ age groups respectively from big to small. There was a statistically significant difference between the 3+ age group and the other 2 age group ($p<0.05$).

The P levels for the 1+, 2+ and 3+ age groups were determined as 11492.0 µg g^{-1}dw, 11362.0 µg g^{-1}dw and 11283.0 µg g^{-1}dw, respectively. The highest level was recorded in the 1+ age group and the lowest level was recorded in the 3+ age group. No statistically significant difference was observed among the age groups ($p>0.05$).

The K levels for the 1+, 2+ and 3+ age groups were found to be 24557.0 µg g^{-1}dw, 21342. 0 µg g^{-1}dw and 19567.0 µg g^{-1}dw, respectively. There was a statistically significant difference for K among the age groups ($p<0.05$).

The calcium level in the muscle tissue is divided into 3+ age group (1194.7 µg g^{-1}dw), 2+ age group (725.5 µg g^{-1}dw) and 1+ age group (348.6 µg g^{-1}dw). Ca level was highest in 3+ age group and lowest in 1+ age group and statistical difference was observed among the age groups ($p<0.05$).

The highest Iron level was detected in the 3+ age group and lowest level in 1+ age group. Fe levels of 1+ age group, 2+ age group and 3+ age group were determined as 27.6 µg g^{-1}dw, 41.7 µg g^{-1}dw and 53.3 µg g^{-1}dw, respectively. There was no statistically significant difference between the 2+ and 3+ age groups ($p>0.05$), but there was a statistically significant difference between the 1+ age group and the other 2 age groups ($p<0.05$).

The level of Zn in the muscle tissue was determined as 8.4 µg g^{-1}dw, 10.3 µg g^{-1}dw, and 9.2 µg g^{-1}dw for the 1+, 2+ and 3+ age groups, respectively. According to age groups, Zn level is highest in 2+ age group and lowest in 1+ age group. No statistically significant difference was observed among the age groups ($p>0.05$).

The decending order of As level in muscle tissue was determined as 1+, 2+ and 3+ age groups. The As levels of 1+, 2+ and 3+ age groups were 44.55 µg g^{-1}dw, 39.53 µg g^{-1}dw and 27.50 µg g^{-1}dw, respectively. The highest As level was detected in the 1+ age group and the lowest in the 3+ age group. There was no statistical difference between 1+ and 2+ age groups ($p>0.05$), but there was a statistically significant difference between them with 3+ age group ($p<0.05$).

4. Discussion

Lambertsen (1998) described fish with 2-4% lipid as low-lipid fish. In our study, the total lipid change range of *N. randalli* was found to be 2.75-2.85%. When the total lipid level of the given scale was evaluated, it was determined that *N. randalli* was low-lipid fish or lean fish. Ramesh et al. (2016) reported low lipid content in *Nemipterus* species (*N. mesoprion* and *N. japonicas*). Researchers

determined the lipid levels of the muscle tissue in the range of 0.36-3.13%. The results of this study support our findings.

Fatty acid Levels (%)

Ramesh et al. (2016) reported that palmitic acid is the dominant saturated fatty acid for in both *Nemipterus* species (*N. mesoprion* and *N. japonicas*). The level of this fatty acid ranged from 12.56 to 27.69%. In our study, the levels of this fatty acid varied between 14.86 and 20.45%. The findings obtained in both studies are similar. In the same study, the levels of stearic acid were found to be between 9.63-15.75% (Ramesh et al., 2016). The levels of this fatty acid in our study were 12.12-13.13%. The findings of both studies were similar in terms of stearic acid level. Researchers reported EPA and DHA levels as 2.19-8.08%, 9.27-28.45%, respectively (Ramesh et al., 2016). In our study, these levels were determined as 3.75-5.49% and 20.16-22.02% respectively. The levels obtained in both studies support each other. The researchers found that the *n*3/*n*6 ratio, which shows the importance of these species in human nutrition, was in the range of 2.25-3.30 (Ramesh et al., 2016). In our study, *n*3/*n*6 ratio was found to be in the range of 12.13-14.06. In terms of *n*3/*n*6 ratio, our findings were higher than those reported in the other study. This difference is due to the fact that the total level of *n*6 (1.97-2.04) obtained in our study was lower than the total level of *n*6 (8.99-14.63) obtained in the other study (Ramesh et al., 2016). While both studies are similar to total *n*3 levels, they are different in terms of *n*6 level. In our study, the AI index was calculated in the range of 0.40-0.53% while the TI index was calculated as 0.29-0.47%. The low values obtained for both indexes indicate that this species is a healthy source for human nutrition. In a similar study (Küçükgülmez et al., 2018), the AI and TI indices of golden grey mullet (*Liza aurata*) and gold band goatfish (*Upeneus moluccensis*) caught from the Northeastern Mediterranean Sea were determined. The results of the study showed that these species are a good source of human consumption in terms of nutritional quality. The results of the researchers support our findings.

Özogul et al. (2009) reported that ∑SFA, ∑MUFA, ∑PUFA, palmitic, palmitoleic, oleic, EPA and DHA levels were 41.14%, 18.07%, 27.35%, 25.5%, 6.9%, 9.39%, 5.39% and 11.40% in *Saurida undosquamis*, respectively. In our findings, ∑SFA, ∑MUFA, ∑PUFA, palmitic, palmitoleic, oleic, EPA and DHA levels were 38.02-42.01%, 15.95-17.35, 26.56-30.13%, 14.86-20.45%, 1.32-1.80%, 5.20-6.47%, 3.75-5.49% and 20.16-22.02%, respectively. Findings related to SFA, PUFA, EPA and DHA were higher than the results of the researchers, our findings with palmitic acid, palmitoleic acid and oleic acid levels were lower than the results of the researchers. Kuzu (2005) reported that the amounts of DHA and EPA in *Mullus barbatus* which is sampled from the Iskenderun Bay were 4.6-10.89% and 4.56-7.93%, respectively. The results of the researchers on EPA were similar to our findings and the results related to DHA were found lower than our findings. The changes in fatty acid composition of fish lipids have been reported to depend on external factors such as water temperature, nutritional composition, and internal factors such as fish life cycle, fish species, nutrition regimen, size, age. The reason why our findings are different from the results of the researchers is due to the difference in catching area and species.

Fatty acid Levels (mg/100g)

Chung et al. (2015) reported the EPA and DHA levels of *N. japonicus* and *N. virgatus* as 89 mg/100g, 173 mg/100g and 116 mg/100g and 363 mg/100g, respectively. In our findings, the EPA level of *N. randalli* was found to be 90.85-135.10 mg/100g, and DHA levels 488.43-541.86 mg/100g. The DHA level in our study is higher than the results of the researchers, while the EPA level is similar in both studies. The EPA levels reported by the researchers support our results.

Element levels

Külcü et al. (2014) have identified metal and mineral contents in the *N. randalli* which is sampled from the Mersin Bay. The levels of Pb, Cu, Zn, Fe, Ca, Mg and P were found to be 5.63 µg g^{-1}dw, 0.24 µg g^{-1}dw, 16.81 µg g^{-1}dw, 85.52 µg g^{-1}dw, 797.07 µg g^{-1}dw, 1758.10 µg g^{-1}dw, and 6793.7 µg g^{-1}dw, respectively. The accumulation level of Zn reported

by researchers is higher than our findings. Findings of researchers on Fe, Mg and P are higher than the levels determined in our study, but Ca level is lower than our findings. It is considered that this may be due to the fact that fish size and age groups are different. Karaytuğ et al. (2018) determined the Fe level as 16.60-38.89 μg g^{-1} in the muscle tissue of *N. randalli*. In our study, Fe level was determined between 27.63 and 53.36 μg g^{-1}. Fe levels in both studies were similar each other. Zn levels in *N. randalli* was found between 11.50-16.19 μg g^{-1} by researchers (Karaytuğ et al., 2018). Zn level was determined in the range of 8.37-10.36 μg g^{-1} in our study. The findings obtained in both studies were similar. The reason for this similarity is that both studies are conducted with the same species in the Mersin Bay. Researchers determined that the level of arsenic in the muscle tissue of *N. randalli* is between 24.66-69.44 μg g^{-1} (Karaytuğ et al., 2018). The arsenic levels obtained in our study was in the range of 27.50-44.55 μg g^{-1}. In both studies, high arsenic levels were obtained in muscle tissue. The presence of this dangerous metal in the Mersin Bay necessitates control of its level in all trophic zones of the food web. Türkmen et al. (2005) reported that, Cd: 1.310-0.831-1.341, Fe: 4.175-9.682-13.166, Pb: 3.474-1.808-2.314, Zn: 3.025-4.078-4.873, Cu: 1.318-2.201-1.239, Mn: 1.361-2.151-1.266, Ni: 6.531-1.359-2.537, Cr: 1.654-2.719-1.309, Co: 2.156-0.953-1.295, Al: 0.831-2.228-0.919 mg/kg (dw) for *S. undosquamis*, *M. barbatus* and *S. aurata* from three different stations in the Iskenderun Bay, respectively. In our study, it was determined that Zn varied between 8.4-10.3 μg g^{-1}dw and Fe levels varied between 27.6-53.3 μg g^{-1} dw. The results of the researchers on Zn and Fe metal were found to be higher than our findings in our study. The reason for this may be that the fish used in the two studies were different species.

5. Conclusion

In the study, the total lipid range was found to be between 2.75-2.85%. *N. randalli* is in the category of "lean fish". From nutritional point of view, it was found that the product contains low levels of lipid and is rich in *n*-3 fatty acids, especially high EPA and DHA levels in each age group. The results have shown that aging affects lipid content and fatty acid composition. According to the British Nutrition Foundation standards, people who have a balanced and healthy diet are recommended to consume 0.2 g EPA + DHA per day. Based on these results, it was determined that the EPA and DHA levels needed for a balanced and healthy diet could be met by 100 g fish consumption in all age groups. DHA levels are higher than other some marine fish. This result is important because this fatty acid is thought to reduce the depression, hypertension, and some other important disorders and it also supports the formation of nerve and brain cells.

Heavy metals such as arsenic, cadmium, lead, copper pass into the water in various ways and accumulate in fish. The age-related decline of arsenic levels in this species is an important outcome in terms of consumption, the reason for preferring large fish for consumption. Phosphorus is the most common mineral in the body after calcium. It is the building material of bones and teeth together with calcium. Enzymes involve phosphorus as regulators of enzyme activities. The bioavailability of phosphorus in animal foods is higher than that of plant foods. For this reason, phosphorus in meat and fish products is better absorbed in humans. A high level of phosphorus is an important output in terms of consumption. Potassium is usually found in the cell and is involved in the regulation of osmotic pressure in the cell. The amount of potassium taken on a normal diet is 2-5.9 g/day, and the minimum requirement for potassium varies from 1.6 to 2 g per day. At present study, the amount of potassium is 2.45 g/100 g (dw). This level also meets the daily potassium requirement. While *N. randalli* can meet the daily intake of essential minerals and fatty acids, it can be considered safe in terms of toxic metals.

Conflict of interests

The authors declare no conflict of interests.

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