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Investigation of the Quality Properties and Nutritional Values of Four Fish Species from Lake Qaroun, Egypt

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Abstract: The objective of the current study were to investigate the proximate, quality criteria, amino acids, fatty acids and major minerals composition in edible part of four commercially well-known fish species from Lake Qarun ; *Tilapia zillii, Solea vulgaris, Mugil cephalus and Metapenaeus stebbing* to determine and compare their quality and nutritional values. According to the results of this study, moisture ranged from 74.85 to 78.80%, protein from 17.70 to 20.11%, fat from 1.57% to 4.48%, ash from 1.33 to 1.70% and energy value was ranged from 68.05 to 117.68 kcal/100g fish muscles**.** *Met. stebbing* had a high ratio of moisture; *M. cephalus* a highest ($P \leq 0.05$) of fat and energy values whereas, *T. zillii* had a high ratio of protein content. Quality criteria; TVB-N, TMA-N, pH and TBC values were much lower than acceptable limits. Regarding amino acids; all investigated fish species had better protein quality as indicated by high of total essential amino acids (EAA), essential amino acids index (EAAI), and biological value (B.V.%), however, *Tilapia zillii* showed the high protein quality followed by, *Solea vulgaris*, *Mugil cephalus* and *Metapenaeus stebbing*. Fatty acid compositions ranged from 26.31% to 43.65% saturated (SFA), 28.75% to 35.45% monounsaturated (MUFAs), 26.45% to 38.42% polyunsaturated acids (PUFAs) of the total fatty acids. ω3/ω6 PUFA and PUFA/SFA ratios ranged from 2,13 to 2.70 and 0.63 to 1.46,respectively. *M. cephalus* and *Met. stebbing* preferred as very good sources of ω-3 fatty acids; Eicosapentaenoic acid (EPA) Docosahexaenoic acid (EPA) and high in ω3/ω6 PUFA and PUFA/SFA ratios followed by *S. vulgaris* and *T. zillii*, respectively. However, *T. zillii* and *S. vulgaris* were good source of SFA. Major minerals; potassium (K), phosphorus (P), calcium (Ca), sodium (Na) and magnesium (Mg) ranged from 280 to 560, 355 to 445, 120 to 185, 48 to 120 and 22 to 75 mg⁄100g fish muscle, respectively. *Met. stebbing* was the highest ($P \leq 0.05$) in concentrations of phosphorus, potassium and sodium minerals, whereas *M. cephalus* highest in calcium and *S. vulgaris* highest in magnesium concentrations. These results can be used as useful references for consumers in order to choose fish based on their quality and nutritional contents.

Keywords: Lake Qarun fish; proximate; Quality Criteria; Amino Acids; Fatty Acids; Major Minerals.

Introduction

Lake Qarun is a closed saline basin located between longitudes of 30° 24' & 30° 49' E and latitude of 29° 24' & 29° 33' N in the lowest part of El-Fayoum depression, about 80 Km south west of Cairo. The Lake has an average area of about 226 km^2, the lake is shallow, with average depth of 4 m. nearly and most of the lake's area has a depth ranging between 5 to 8 meters. The Lake receives annually about 470 million cubic

metres of drainage water (agricultural and sewage) through 12 drains in which El-Batts and El-Wadi drains carry most of the water brought to the lake[1].

Fish is a major source of food for mankind, providing with a significant amount of the animal protein diet, excellent dietary sources of highly unsaturated fatty acid (UFA) and polyunsaturated fatty acid (PUFA), especially the omega-3 fatty acids, Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA) [2]. Marine fish species contributes extremely to the delivery of macro and micro nutrients in our normal food diet. The proximate composition, amino acid value and fatty acid composition of fish are varied from one to another species. It is depending on age, sex, environment and season variations. The biochemical compositions are closely connected to feeding habit, migration and sexual changes in connection with spawning[3]. The most important minerals in the fish and shell fish are potassium and calcium followed by phosphorus which is important for proper functioning of the nerves and bone formation. These minerals are generally higher in marine fish than in fresh water fish[4]. Determination of proximate composition as protein, carbohydrates, lipids, ash and moisture contents as well as vitamins and minerals plus the caloric value is often necessary to ensure that fish tissues have a good nutrition quality and nutritional value that they meet the requirements of food regulations and commercial specifications; also, the quality of fish tissue is function of their body compositions and energy values, which that vary among different species[5].

Generally, fish flesh is basically composed of water (66-81%), protein (16-21%), carbohydrates (<0.5%), lipids (0.2-25%) and ash (1.2 to 1.5%) [6]. Also, fish is known to be a source of protein rich in essential amino acids (lysine, methionine, cystine, threonine, and tryptophan). Amino acids play a vital role both as building blocks of proteins and as intermediates in metabolism and further help to maintain health and vitality and the evaluation of protein quality is carried out on the basis of the amounts of essential amino acids[7]. The marine fish oil is one of the most significnt natural sources of polyunsaturated fatty acids (PUFA) like n-3 PUFA has raised concentration due to it can prevent human cardiovascular disease, anti-inflammatory, anti thrombotic effects, reduction of blood cholesterol level and prevention of cancer[8].

Moreover, fish is one of the potential (best and cheapest) sources of animal protein of very high digestibility and essential nutrients for the maintenance of a healthy body particularly of the low and middle income groups. Currently, all over the world, sea food is encouraged because of its beneficial effects to fight diseases and for maintenance of good health[9]. Thus, the nutritional importance of fish consumption to a great extent associated with its protein, unsaturated essential fatty acids and minerals.

Therefore, the objective of this work was to determine and compare the chemical composition, quality criteria, amino acid, fatty acid as well as major minerals of four economic important various fish species muscles from Lake Qarun (*Tilapia zillii, Solea vulgaris, Metapenaeus stebbing* and *Mugil cephalus*) to evaluate their nutritional composition and nutritive value because these fish species have been consumed as food by local people in Fayoum Governorate.

Materials and methods

Samples collection

Four marine fish species were used for the experiment; they are: Bolti *(Tilapia zillii*, 5kg, 80 ±20g*)*, Solea (*Solea vulgaris*, 3kg, 60 ±15g*)*, Bouri (*Mugil cephalus*, 5kg, 220 ±50g), Shrimp *(Metapenaeus stebbing*, 4kg, 12 ±3g*)* were purchased from local fish market on the shore of Lake Qarun, El Fayoum Governorate, Egypt in November 2014. Fish samples were placed with granulated ice in icebox and transported directly within about 2 hrs to the Laboratory of Fish Processing and Technology in El-Kanater El-Khairia, Fish Research Station, National Institute of Oceanography and Fisheries.

Analytical methods

Chemical Composition:

Moisture, crude protein (N×6.25), crude fat and ash contents were determined according to the standard methods recommended by AOAC[10]. Carbohydrate was calculated using the standard equation 100% - (% protein + % fat + % ash + % moisture) and the energy evaluation was done by multiplying the protein, carbohydrate and fat with the factors 4, 4 and 9, respectively according to the methods recommended by[5].

Quality Criteria:

Total volatile basic nitrogen (TVB-N) was determined by macro distillation method proposed by[11]. Trimethylamine nitrogen (TMA-N) was determined according to[10]. The pH value was measured according to the method described by[12]. Total bacterial count (TBC) was determined using nutrient agar medium according to the[13] and the results were expressed as Log_{10}cfu/g sample.

Amino Acids:

Amino acids were determined by using HPLC & Amino acid analyzer LC3000 Eppendr of Germany in National Research Center according to the method described by[14]. Tryptophan was determined colourmetrically as described by[15]. Evaluation of nutritional protein was carried out by determined essential amino acids index (EAAI) calculated according to[16] and biological value (B.V. %) calculated as recorded by[17].

Fatty Acids:

Total lipids in muscle tissue were extracted using a chloroform-methanol solution (1:1, v/v) by the[18]. Fatty acid composition was determined by preparing methyl esters and analyzing them by gas chromatography[19] in Faculty of Agriculture Research Park (FARP), Cairo Univ. Fatty acids were identified by comparison of retention times with a mixture of fatty acid standards. Each fatty acid was quantified by calculating its peak area relative to the total peak area.

Major minerals:

Phosphorus (P), calcium (Ca), potassium (K), sodium (Na), and magnesium (Mg) were determined as described by the[10] in the Chemistry Laboratory, Fresh Water and Lakes Division, National Institute of Oceanography and Fisheries.

Statistical Analysis:

Data of chemical composition, quality criteria and major minerals were analyzed statistically using the least significant difference test (L.S.D) at $(P \leq 0.05)$ and Standard Deviation (Mean ± SD) which calculated using SPSS 10.0 for windows[20].

Results and discussion

Chemical composition of some commercial important fish species from Lake Qarun

Table 1 represents the concentration and percentage of proximate composition (that is, moisture, protein, fat, ash and carbohydrates) and the caloric value of the selected fish species. The moisture content was ranged from 74.85% to 78.80, protein from 17.70% to 20.11%, fat from 1.57% to 4.48%, ash from 1.33% to 1.70 and carbohydrates content from 0.15% to 0.3 % (on wet basis). In any case, the proximate compositions of the fish that have been inspected in this study are healthy and the fish species examined belonged to high protein because the protein contents were between 15 to 20%[21], about crude fat content, T. *zillii* and *Met. stebbing* were identified as lean fish, *S. vulgaris* as low fat fish, *M. cephalus* as medium fat fish; where, fish species are generally grouped into four categories based to their fat contents: lean fish (<2%), low fat (2-4%), medium fat (4-8%) and high fat (>8 %) [22].

In addition to, all values were within the normal ranges of proximate composition (water 66-84%, protein 15-25 %, fat 0.1 -24 %) [23]. Also, [13] illustrated that fish flesh contains of water (66-81%), protein (16-21%), carbohydrates (<0.5%), lipids (0.2-25%) and ash (1.2 to 1.5%). From results, significant and insignificant differences ($P<0.05$) were found in proximate composition between investigated fish species and the fish samples analyzed presented highest to lowest amounts of moisture, protein and fat contents in the order: moisture, *Met. stebbing* > *S. vulgaris* > *T. zillii* > *M. cephalus*. Protein, *T. zillii* > *M. cephalus* > *S. vulgaris* > *Met. stebbing*. Fat, *M. cephalus* > *S. vulgaris* > *T. zillii* > *Met. stebbing*. Thus, Met. *stebbing* is a low fat and low protein fish with the highest amount of moisture, while *M. cephalus* is a high fat content and contains the least amount of moisture. Low fat fish species have higher water content and as a result, their flesh is whiter in color[22, 24]. These differences in the nutritional compositions of different species may be attributed to food

composition, food and feeding habit, feeding rate, habitats, sex, age, size, genetic traits, different geographical locations and in different seasons[25]. Also, significant differences (P<0.05) were found in caloric value between all fish species. Energy value was ranged from 68.05 to 117.68 kcal/100g fish muscles. The highest caloric value was obtained for *M. cephalus* followed *S. vulgaris, T. zillii* and *Met. stebbing* has the least value, mainly due to their fat contents.

These results are in agreement with reported by[26] who found that shrimp fish obtained from Lake Qarun contains 76.32% moisture, 18.21% crude protein, 1.87% crude fat, 1.77% ash. Also, [27]reported that the chemical composition of fresh *T. zillii* obtained from Lake Qarun were 76.64 % moisture, 19.34% protein, 2.55% lipid and 1.43% ash. [28]found that moisture, protein, fat and ash contents of fresh grey mullet from Lake Qarun were 78.11, 17.99, 2.46 and 1.39% respectively. Therefore, these results indicated that all investigated fish species were high in protein and moderate in fat contents especially *T. zillii* was high in protein, whereas *M. cephalus* was high in fat content and energy value.

Table 1 Chemical composition (Mean ± SD) of commercially well-known fish species from Lake Qarun (on wet basis)

Constituents (%)	**Fish species**				
	M. cephalus	***S. vulgaris***	***T. zilli***	***Met. stebbing***	***L. S. D. at 5 %***
Moisture	74.85±0.45	77.10±0.85	76.04±0.25	78.80±0.75	1.22
Crude protein	19.10±0.15	18.95±0.22	20.11±0,04	17.70±0.32	0.11
Crude fat	4.48±0.09	2.65±0.12	1.85±0.09	1.57±0.11	0.23
ash	1.33±0.32	1.15±0.41	1.70±0.14	1.65±0.08	0.06
carbohydrates	0.24±0.05	0.15±0.08	0.30±0.10	0.28±0.05	0.03
Energy value (kcal/100g)	117.68±0.09	100.25±0.54	98.29±0.65	86.05±0.15	1.42

Quality criteria of some commercial important fish species from Lake Qarun

The total volatile basic nitrogen (TVB-N) values of investigated fresh fish were 10.20, 12.22, 14.35 and 15.80 mg N/100g flesh (on wet basis) for *S. vulgaris*, *M. cephalus*, *T. zillii* and *Met. stebbing*, respectively (Table 2). Significant differences (P<0.05) were shown among all four fish types, all fish species showed submaximal acceptable levels; the level of TVB-N for white fish is generally considered to be fresh if the TVB-N is less 20 mg N/100g sample according to the Codex Alimentations Committee proposed in 1968. However, levels exceeding 28 mg TVB-N/100g has been reported "unacceptable" according to the Turkish Manual of Seafood Quality Control Limits[29]. Also, [30]suggest that fish and fish products is unfit for human consumption when exceeding the value (TVB-N) 30 mg N/100g flesh. Therefore, these TVB-N values of investigated fish species were much lower than acceptable limit which ranged between 30 – 40 mg N/100g samples[31]. Regarding TMA-N values, the results of the present study indicated that *S. vulgaris* showed rather low value of trimethylamine nitrogen (TMA-N) 0.48 mg N/ 100g flesh, whereas *M. cephalus, T. zillii* and *Met. stebbing* showed higher TMA-N values 0.62, 0.68 and 0.95 mg N/100g sample, respectively. Significant differences (P<0.05) appeared among all four types. It has been mentioned that fresh fish with less than 1.5 mg TMA-N/100g flesh is considered as good quality and 10-15mg TMA-N /100g is regarded within the acceptable limits[31] while, [32]reported that when TMA value increases to more than 10 mg N/100g flesh, the fish meat is considered stale.

pH value is the only measurement which has been commonly used as physical method for quality assessment of fish meat [33]. The pH values were 6.07, 6.11, 6.30 and 6.25 of *S. vulgaris, M. cephalus, T. zillii and Met. stebbing* respectively, these values of pH indicated that all tested fish were high fresh.

Also, total bacterial count (TBC) is shown also in (Table 2), *S. vulgaris* and *M. cephalus* had low TBC; 1.95, 2.05 Log_{10} cfu/g, respectively. While, *T. zillii,* and *Met. stebbing* had higher TBC; 2.40 and 2.75 Log_{10} cfu/g flesh, respectively. Insignificant difference (P<0.05) was found in total bacterial count (TBC) between *S.*

vulgaris and M. cephalus, while significant difference (P<0.05) was found between *T. zillii* and *Met. stebbing* and with *M. cephalus* and *S. vulgaris.* The results of TBC for all fish types were within the standard range (5×10^5 -10^7 cfu /g) for fresh fish according to[34]. The standard ranging bacterial count of the current study demonstrated an acceptable quality. The high total plate count, which may exceed the standard maximal limits, may be related to bad handling and mechanical damages during fishing as well as the time of exposing fish to air. [35]found that the total plate count of fresh fish $<10^4$ cells/g, sub fresh 10^4-10^6 cells/g and deteriorated fish > 10^6 cells/g.

These results indicated that *S. vulgaris* was high quality and safe followed by *M. cephalus, T. zillii and Met. stebbing,* respectively, due to lower TVB-N, TMA-N, pH and TBC values. These results are in agreement with reported by[26] who found that TVB-N, TMA-N, pH and TBC values of Lake Qarun shrimp were 8.86, 0.66 mg /100g flesh, 6.27 and 1.03 x 10^3 cell /g respectively. Also, [36]reported that tilapia and mullet fish contains 14.31 and 12.05 mg TVB- N/100g flesh, 0.92 and 0.68 mg TMA-N /100g flesh, 6.07 and 5.94 pH value and 2.35 and 2.01 Log_{10} cfu/g flesh TBC respectively.

Table 2 Quality criteria (Mean ± SD) of commercially well-known fish species from Lake Qarun (on wet basis)

Q. criteria	Fish species				L. S. D. at 5 %
	M. cephalus	*S. vulgaris*	*T. zillii*	*Met. stebbing*	
TVB-N	12.22± 0.06	10.20±0.14	14.35± 0.08	15.80± 0.13	0.38
TMA-N	0.62± 0.09	0.48± 0.11	0.68± 0.22	0.95± 0.35	0.12
pH	6.11± 0.12	6.07± 0.03	6.30± 0.06	6.25±0.05	0.09
TBC (Log_{10}cfu/g)	2.05± 0.15	1.95± 0.31	2.40± 0.31	2.75± 0.08	0.20

TVB-N: Total volatile basic nitrogen (mg N/100gm sample).
TMA-N: Trimethylamine nitrogen (mg N/100gm sample).
TBC: Total bacterial count (Log_{10}cfu/g sample).

Amino acid composition and nutritional quality of some commercial important fish species from Lake Qarun

The nutritional value of protein is obviously reflected upon it essential amino acids content. The essential amino acids composition as (g/100g protein) of investigated four fish species is shown in Table 3. It could be noticed that, nine essential amino acids namely lysine, valine, leucine, isoleucine, threonine, phenylalanine, methionine, histidine and tryptophan that are very important for human health were present in all the fish species examined. Therefore these species would be very good source of these amino acids in our diet. Also, all fish species under study had much higher content (g/100g protein) of all essential amino acids (EAA) than those of reference protein pattern[37]. From results; essential amino acids (lysine, phenylalanine + tyrosine, valine and leucine) were to be the highest values (P<0.05) of all fish species respectively, ranged from 5.05 to 10.70 g/100g protein, while, tryptophan followed by histidine were the lowest levels, respectively ranged from 0.97 to 2.23 g/100g protein. The other essential amino acids (therionine, isoleucine and methionine + cystine) were found at nearly similar amounts ranged from 3.15 to 4.24 g/100g protein.

From the same Table 3, it could be found a significant difference (P<0.05) between all different fish species when comparing the nutritional value; total essential amino acids (TEAA), essential amino acids index (EAAI) and biological value (B.V. %); *Tilapia zillii* contain the high amount of TEAA (43.62g/100g protein), EAAI (81.11) and B.V. (76.68 %). The other fish species could be descending according their sum of TEAA, EAAI, B.V. % as follows: *Solea vulgaris* (42.74g/100g protein, 79.72, 75.16%), *Mugil cephalus* (42.09g/100g protein, 78.81, 74.17%) and *Metapenaeus stebbing* (40.97g/100g protein, 76.78, 71.96%) respectively.

Therefore, it could be concluded that all investigated fish species had better protein quality and nutritional value as indicated by high of (EAA), (EAAI), and (B.V. %). So, *Tilapia zillii* showed the high

quality and nutritional value of protein followed by *Solea vulgaris* and *Mugil cephalus* while, the lowest values of the same parameters were recorded for *Metapenaeus stebbing*. These results were in agreement with[26, 7, 38].

Table 3 Essential amino acids composition and nutritional quality of commercially well-known fish species from Lake Qarun

Fish species EAA	FAO/WHO/ UNU (1985) (g/16g N)	*M. cephalus*	*S. vulgaris*	*T. zillii*	*Met. Stebbing*
Lysine	1.6	9.20	10.12	10.70	9.25
Therionine	0.9	4.24	4.10	3.95	4.22
Tryptophan	0.5	1.10	1.85	2.05	0.97
Leucine	1.9	5.95	5.19	5.05	5.30
Isoleucine	1.3	3.15	3.55	4.12	3.18
Valine	1.3	6.05	5.97	6.12	6.01
Methionine + Cystine	1.7	3.68	3.36	3.87	3.56
Phenylalanine + Tyrosine	1.9	6.52	6.45	5.88	6.25
Histidine	1.6	2.20	2.15	1.88	2.23
TEAA		42.09	42.74	43.62	40.97
E.A.A.I.		78.81	79.72	81.11	76.78
B.V. %		74.17	75.16	76.68	71.96

EAA: Essential amino acids. TEAA: Total essential amino acids.
EAAI: Essential amino acids index. B.V %: Biological value.

Fatty acid composition and nutritional quality of some commercial important fish species from Lake Qarun

Analyses of the muscle fatty acid profile of examined fish species obtained from Lake Qarun are shown in Table 4. Results of this study showed that twenty fatty acids in muscle were identified and evaluated. The average of total saturated fatty acids (SFA); 26.31% (*M. cephalus*) to 43.65% *(T. zillii*), mono unsaturated fatty acids (MUFA); 28.75% *(T. zillii)* to 35.45% *(Met. stebbing*) and poly unsaturated fatty acids (PUFA) 26.45% *(T. zillii)* to 38.42% *(M. cephalus*) while, unidentified fatty acids were found about 1.15 to 3.15% of total fatty acids. Distribution of fatty acids contents in all investigated fish species were SFA>MUFA>PUFA. It could be noticed that, of the SFA, (palmitic acid) C16:0 and (stearic acid) C18:0 were prominent SFA in all fish species and were highest in *T. zillii* and *S. vulgaris* accounted for 66.78% and 16.56% respectively of the total SFA. [39] found that palmitic acid was the predominant saturated fatty acid in both marine and fresh water fish.

In the same Table 4, it was found that monoenoic fatty acids MUFA such as oleic acid (C18:1 ω-9) was the most abundant and palmitoleic acid (C16:1 ω-7) was the second of monounsaturated fatty acids in all fish species. Oleic acid was highest level (76.81% of total MUFA) for *M. cephalus*, while palmitoleic acid was highest level (21.02% of total MUFA) for *Met. stebbing*. Oleic acid is the prominent MUFA and it was found in higher levels in fresh water fish than in marine fish[39]. Polyunsaturated fatty acids (PUFA) represent the most important fatty acids in fish muscles their abundance is in accordance with (ω-3). The obtained results revealed that ω-3 series of all fish species are good source of Eicosapentaenoic acid (EPA) C20:5ω-3, ranged from 4.06% for *T. zillii* to 8.06% for *M. cephalus* and Docosahexaenoic acid (DHA) C22:6ω-3 from 11.98% for *T. zillii* To 17.40% for *Mugil cephalus* while, ω-6 series are good source of Arachidonic acid (AA) C20:4ω-6 from 5.00% for *T. zillii* to 5.85% for *Met. stebbing*. The (ω-3)/ (ω-6) ratio is very important to evaluate oil fish nutritional value[40].

The results of this study indicated that the ω3/ω6 PUFA ratios were ranged from 2.13 for *T. zillii* to 2.70 for *M. cephalus* and higher than (1). [41]found that ω3/ω6 ratio of 1:1 is considered to be optimal for nutritional purpose. However, higher the ω3/ω6 ratios, increases the body's ability to use the ω3 oils. Therefore, the contents of two fatty acids namely DHA and EPA are responsible to the greatest extent for changes in the

ω3/ω6 ratios, a reliable indicator that enables a comparison of relative nutritive value of fish oils. Also, whether the diet is natural or compounded, the fatty acid an increase in the human dietary ω3/ω6 fatty acid ratio is essential to help prevent coronary heart disease by reducing plasma lipids and to reduce the risk of cancer[42].

Also, it was noticed that the PUFA/SFA ratios obtained in this study ranged between 0.63 for *T. zillii* and 1.46 for *M. cephalus*, these values were higher than recommended ratios (0.45) HMSO. [43] revealing that *M. cephalus* followed by *Met. stebbing* are good sources of PUFA followed by *S. vulgaris* and *T. zillii*, respectively. Thus, PUFA/SFA ratio was considered the key factor also for evaluation of fish nutrition quality. [44] found that the ratio PUFA/SFA was 1.13 in common Kilka which was more than the recommended minimum value. However, [45] found it to be 0.53 in *C. caspia*. Although it is generally recognized that the PUFA composition may vary among species of fish, little attention has been paid to the PUFA composition of different species when selecting fish for diets.

Therefore, the present study suggests that *M. cephalus* and *Met. stebbing* may be preferable as a result of their very good sources of ω-3 fatty acids; (EPA) and (DHA) found only in seafood and high in ω3/ω6 PUFA and PUFA/SFA ratios followed by *S. vulgaris* and *T. zillii*, respectively. However, *T. zillii* and *S. vulgaris* were good source of SFA.

Table 4 Fatty acid composition (% of total fatty acids) and nutritional quality of commercially well-known fish species from Lake Qarun

Fatty acids	**M. cephalus**	**S. vulgaris**	**T. zillii**	**Met. Stebbing**
Saturated Fatty Acids (SFA)				
C 14:0 (Miristic acid)	2.29	2.62	4.31	1.85
C 15:0 (Pentadecanoic acid)	0.35	0.50	0.76	0.29
C 16:0 (Palmitic acid)	17.20	25.46	29.15	18.60
C 17:0 (Heptadecanoic acid)	0.35	0.55	0.80	0.72
C 18:0 (Stearic acid)	4.75	6.06	7.23	4.03
C 20:0 (Arachidic acid)	0.85	0.95	1.12	0.70
C 22:0 (Behenic acid)	0.52	1.06	0.28	1.86
Total SFA	26.31	37.20	43.65	28.05
Monounsaturated Fatty Acids (MUFA)				
C16:1 ω-7 (Palmitoleic acid)	4.46	5.36	6.88	7.45
C17:1 (Heptadecanoic acid)	0.80	0.77	0.90	1.22
C18:1 ω-9cis (Oleic acid)	25.90	22.09	17.57	23.65
C20:1 ω-9 (Eicosenoic acid)	1.33	1.62	1.30	1.65
C22:1 ω-9 (Erucic acid)	0.92	1.15	1.55	0.75
C24:1 ω-9 (Nervonic acid)	0.31	0.41	0.55	0.73
Total MUFA	33.72	31.40	28.75	35.45
Polyunsaturated Fatty Acids (PUFA)				
C18:2 ω-6 cis Linoleic acid (LA)	4.68	3.38	3.16	2.50
C18:3 ω-3 α- linolenic acid(ALA)	0.65	1.33	0.77	1.07
C20:2 ω-6 Eicosadienoic acid	0.95	0.40	0.28	0.66
C20:3 ω-3 Eicosatrienoic acid	1.56	1.05	1.20	2.15
C20:4 ω-6 Arachidonic acid(AA)	5.12	5.25	5.00	5.85
C20:5 ω-3 Eicosapentaenoic acid(EPA)	8.06	5.88	4.06	6.45
C22:6 ω-3 Decosahexaenoic acid(DHA)	17.40	12.31	11.98	14.67
Total PUFA	38.42	29.60	26.45	33.35
PUFA/SAF ratio	1.46	0.80	0.63	1.19
Omega-3 series (ω-3)	27.67	20.57	18.01	24.34
Omega-6 series (ω-6)	10.75	9.03	8.44	9.01
ω-3/ω-6	2.57	2.28	2.13	2.70
Unidentified	1.55	1.80	1.15	3.15

Major minerals

Marine fish are very rich sources of mineral components. The total content of minerals in the flesh of marine fish and invertebrates is in the range of 0.6-1.5% wet weight[30]. Table 5 shows the mineral composition of four marine fish muscles from Lake Qarun; *M. cephalus, S. vulgaris, T. zillii* and *Met. stebbing*. All fish species that were tested contain significant concentrations of major minerals; potassium (K), phosphorus (P), sodium (Na), calcium (Ca) and magnesium (Mg) indicating that these species can be used as good sources of minerals. It could be noticed that the presence of significant difference ($P<0.05$) between the concentrations of major minerals and between different species of fish in this study.

Potassium concentration was the highest ($P<0.05$) followed by phosphorus, sodium and calcium, while magnesium showed medium concentration in all fish species. A highest level of K was found in *Met. stebbing* followed by *M. cephalus*, *T. zillii* and *S. vulgaris* with 560, 412, 320 and 280 mg/100g fish muscle (on wet basis)., respectively. K is an essential element in the body system that plays a vital role in protein synthesis, nerve conduction; control of heart beat, muscle contraction and synthesis of nucleic acids[46]. Most people need between 2-4 g per day on average from K element[47]. The values of Na were higher significantly ($P<0.05$) in *Met. stebbing* (120 mg/100g) whereas, the lowest concentrations were found in *S. vulgaris* (48 mg/100g fish muscle). Na is an important element to human life. It plays a significant role in the blood plasma and normal functioning of nervous system. The human sodium requirement is about 3 g per day[47]. Also, in this study, Ca contents in the fish species ranged from 120 (*T. zillii*) to 185 mg/100g (*M. cephalus*). The fish meat generally contains high calcium content than the animal meat[48]. Ca has important physiological and biochemical roles in humans. Besides its vital role in bone structure, calcium plays an integral role in the maintenance of normal blood pressure, and adequate calcium intake may help reduce this risk of high blood pressure[49]. Regarding P contents; the fish species, *Met. stebbing* had the highest phosphorus contents ($P<0.05$) of 445 mg/100 g fish muscle whereas, the species, *S. vulgaris*, *M. cephalus* and *T. zillii* had lower phosphorus values of 430,410 and 355 mg/100 g, respectively. The RDA (Recommended Dietary Allowance) for P is 300-450 mg per day[47].

The values of Mg content in muscle of fish samples varied from 22 (*M. cephalus*) to 75 mg/100g fish muscle (*S. vulgaris*) in this study. The RDA for Mg is 2000 mg per day[47]. Mg functions as a cofactor of many enzymes involved in energy metabolism, protein synthesis, RNA and DNA synthesis, and maintenance of the electrical potential of nervous tissues and cell membranes[6]. From the study, it can be concluded that the fish of *Met. stebbing* was the highest in concentrations of phosphorus, potassium and sodium minerals whereas, *M. cephalus* Highest in calcium and *S. vulgaris* highest in magnesium concentrations. This observation was supported by a finding of [50] which shows that variation in concentrations of these mineral elements from one species to another was due to the chemical forms of the elements and their concentration in the local environment. These results are in agreement with reported by[51, 4, 52].

Table 5 Major minerals composition (wet matter basis) of commercially well-known fish species from Lake Qarun

Fish species	**Minerals (g/100g)**					
	Calcium (Ca)	**Phosphorus (P)**	**Potassium (K)**	**Sodium (Na)**	**Magnesium (Mg)**	**L. S. D. *at 5 %***
M. cephalus	185 ±0.12	410±0.08	412±0.42	85±0.11	22±0.30	0.24
S. vulgaris	122±0.09	430±0.22	280±0.13	48± 0.05	75 ± 0.21	0.55
T. zilli	120± 0.16	355 ±0.06	320± 0.08	55± 0.01	45±0.10	0.29
Met. stebbing	160 ±0.02	445±0.01	560± 0.08	120±0.14	68±0.05	0.46
L. S. D. *at5 %*	0.67	0.55	0.23	0.40	0.23	

Conclusion

From this study, it could be concluded that significant and insignificant differences ($P<0.05$) were found in analysis of proximate composition, quality criteria, amino acids, fatty acids and major minerals between different investigated fish species from Lake Qarun. All investigated fish species were high in protein and moderate in fat contents; *Met. stebbing* was a high of moisture; *M. cephalus* a high of fat and energy value while, *T. zillii* a high of protein content. All investigated fish species were high quality and safety due to lower TVB-N, TMA-N, pH and TBC values. Also, all fish species had better protein quality as indicated by the high of total essential amino acids (EAA), essential amino acids index (EAAI), and biological value (B.V. %) so, *T. zillii* showed the high quality of protein followed by *Solea vulgaris*, Mugil *cephalus* and *Metapenaeus stebbing*. Fatty acids; palmitic and stearic acids were prominent SFA in all fish species. Oleic and palmitoleic acids were the most abundant of MUFA. PUFA; Eicosapentaenoic and Docosahexaenoic acids (ω-3 fatty acids) represent the most important fatty acids in fish. Therefore, *Mugil cephalus* followed by *Metapenaeus stebbing* preferable as good sources of ω-3 fatty acids while, *Solea vulgarism* and *Tilapia zillii* a good sources of saturated fatty acids. Major minerals, *Met. stebbing* was the highest in concentrations of phosphorus, potassium and sodium, minerals, while *M. cephalus* Highest in calcium and *S. vulgaris* highest in magnesium concentrations. These values are useful references for consumers in order to choose fish based on their nutritional contents.

References

1. Abdel-Satar, A. M.; Goher, M. E. and Sayed, M. F. (2010): Recent Environmental changes in water and sediment quality of Lake Qarun. Egypt. Journal of Fisheries and Aquatic Science, 5 (2): 56 – 69.
2. Feng, Z.; Ping, Z. and Chao, S. (2010): Amino acid and fatty acid composition and nutritional quality of muscle in the pomfret (*Pampus punctatissimus*). Journal Food Chemistry, 2:224-227. Doi: 10. 1016 / J. Foodchem. 2009. 04.110.
3. Love, R. M. (1988): The Food Fishes: Their Intrinsic Variation and Practical Implications, Reinhold N, (Ed.), New York..
4. Palani kumar, M. 1. ; Ruba Annathai, A. 1. ; Jeya Shakila, R. 1. and Shanmugam, S. A. (2014): Proximate and major mineral composition of 23 medium sized marine fin fishes landed in the Thoothukudi Coast of India. J. Nutr. Food Sci. 2014, 4:1.
5. WHO/FAO (2011): Report of the joint FAO/WHO expert consultation on the risks and benefits of fish consumption. Rome, Food and Agriculture Organization of the United Nations; Geneva, World Health Organization, 50 pp.
6. FAO/WHO (1998): Expert vitamin and mineral requirements in human nutrition: report of a joint FAO/WHO expert consultation. Bangkok, Thailand, 21-30 September 1998.
7. Osibona, A. O. (2011): Comparative study of proximate composition, amino and fatty acids of some economically important fish species in Lagos, Nigeria. African Journal of Food Science, Vol. 5 (10), pp. 581-588.
8. American Heart Association (2002): Fish oil and omega-3 fatty acids. American Public Health Administration.
9. Carroll, K. K.; Woodward, C. J. H. (1989): Marine biogenic lipids, fats and oils. In: Ackman RG (Editor), CRC Press, Inc, BOCA Raton, Florida, USA, 2: 435-479.
10. AOAC (2002): Association of official analytical methods. Official Methods of Analysis. 16th Ed. Arlington, Virginia. USA.
11. Pearson, D. (1991): The Chemical Analysis of Food. Churchill, New York, London, PP: 374 - 410.
12. Naveena, B. M. and Mendiratta, S. K. (2001): Tenderization of spent hen meat using ginger extract. British Poultry Science, 42: 344–350.
13. FAO (1992: Food and Agriculture Organization. Manual of Food Quality Control, 4, Rev. 1 Microbiological Analysis, 1992. Rome.
14. Andrews, S. R. and Blader, N. (1985): Amino acid analysis of feed constituents. Science Tools, 32:44.
15. Sastry, C. S. P. and Tammura, M. K. (1983): Spectrophotometer determination of tryptophan in protein. J. Food Sci. Technol. 22: 146-147.
16. Hidvegi, M. and Bekes, F. (1983): Mathematical modeling of protein nutritional quality from amino acids composition. Proc. Int. Assoc., Cereal Chem. Symp. Amino acid composition and biological value of cereal proteins. Budabest, Hungari, 1983.

17. Oser, B. L. (1959): An integrated essential amino acid index for predicting the biological value of proteins. Ed. Albanese, A. A. P. 281, Academic Press, New York.
18. Bligh, E. G. and Dyer, W. J. (1959): A rapid method of total lipid extraction and purification. *Can. J. Biochem. Physiol*., 37: 911–917.
19. AOCS (1992): AOCS (American Oil Chemists' Society). Fatty acid composition by GLC. Marine oils. AOCS Official Methods Ce 1b-89, AOCS, Champaign, IL.
20. SPSS (1991): Statistical Package for Social Science.
21. Stansby, M. E. (1982): Properties of fish oils and their application to handling of fish and to nutritional and industrial use. In: Chemistry and Biochemistry of Marine Food Products. (Martin, R. E.; Flick G. J.; Hebard, C. E. and Ward; D. R. Eds.). pp. 75-92. Avi Publishing Co., Westport, CT.
22. Ackman, R. G. (1989): Nutritional composition of fats in seafood's. Progress in Food and Nutrition Science, 13: 161-289.
23. Huss, H. H. (1995): Quality and quality changes in fresh fish. FAO Fisheries Technical Paper 348. pp. 130–131. Rom: FAO.
24. Osman, H.; Suriah, A. R. and Law, E. C. (2001): Fatty acid composition and cholesterol content of selected marine fish in Malaysian water. Food Chemistry 73: 55-60.
25. Abdulkarim, B.; Bwathondi, P. O. and Benno, B. L. (2015): Seasonal variations in the mineral composition of some commercially important fish species of Lake Victoria-Tanzania. International Journal of Agricultural Sciences. Vol. 5 (3), pp. 426-434.
26. El-Sherif, S. A. (2001): Chemical and technological studies on shrimp and its wastes. Ph.D. Thesis, Fac. of Agric. Fayoum, Cairo Univ.
27. Ibrahim, S. M.; El-Sherif, S. A. and Abo-Taleb, M. (2013): Effect of grilling process on heavy metals concentrations in some fish muscles, Lake Qarun, Egypt. Blue Biotechnology J. Vol. 1, N.4, 2013.
28. Mohamed, H. R. (2013): Application of hazard analysis critical control points (HACCP) system on fish salting. M. SC. Thesis, Fac. of Agric. Fayoum, Fayoum Univ.
29. Anonymous (2008): Regulations for Changing in Turkish Manual of Seafood Quality Control Limits. Turkish Republic Formal Paper, 21st of September, 2008, No. 27004.
30. Sikorski, Z. E.; Lolakowska, A. and Pan, B. S. (1990): The nutritive composition of the major groups of marine food organisms. In Sikorski Z. E. (Ed). Resources Nutritional composition and preservation. PP. 30-52. Bola Raton, Florida: CRC Press – Inc.
31. Connell, J. J. (1976): Control of Fish Quality. Fishing New Books, NY, pp: 127-129.
32. Dalgaard, P.; Gram, L. and Huss, H. H. (1993): Spoilage and shelf life of cod fillets packed in vacuum or modified atmospheres. Int. J. Food Microbiology, 19: 283–294.
33. Mhongole, J. M. (2009): Microbiology and Spoilage Trail in Nile Perch (Lates niloticus), Lake Victoria, Tanzania. Thesis of degree of M. Sc. Food Science (Seafood processing). Faculty of Food Science and Nutrition School of Health Sciences. University of Iceland.
34. ICMSF (1986): International Commission on Microbiological specifications for Food of the International Union of Microbiological Societies. Microorganisms in Food. 2: Sampling for microbiological analysis principles and Specific Application, 2nd Ed., University of Toronto Press, Toronto, Canada.
35. Shen, L. (1996): Amperometric determination of freshness by a hypoxanthine biosensor. J. Sci. Food Agric., 70: 289-302.
36. El-Sherif, S. A.; Ibrahim S. M. and Mohamed Abo-Taleb (2011): Relationship between frozen pre-storage period of raw tilapia and mullet fish and quality criteria of its cooked products.
37. FAO/WHO/UNU (1985): Energy and protein requirements. Report of joint FAO/WHO/UNU. Expect Consulation, World Health Organization. Technical Report Series 724, WHO, Geneva.
38. Oğuz, T.; ÖZCAN, F. and ERBAŞ, C. (2013): Determination of proximate and amino Acid composition of five different tilapia species from the Cukurova region (Turkey). Journal of Applied Biological Sciences 7 (3): 17-22,
39. Gutierrez, L. E. and Silva, R. C. M. (1993): Fatty acid composition of commercially important fish from Brazil. Scientia Agricola (Piracicaba, Brazil), 50(3): 478-483.
40. Piggot, G. M. and Tucker B. W. (1990): Effects of technology on nutrition. Marcel Dekker, New York.
41. Simopoulos, A. P. (1989): Summary of NATO advanced research workshop on dietary n-3 and n-6 fatty acids: biological effects and nutritional essentiality. *J. Nutr*., 199: 512–528.
42. Kinsella, J. E.; Lokesh, B. and Stone, R. A. (1990): Dietary n-3 polyunsaturated fatty-acids and amelioration of cardiovascular disease-possible mechanisms. Am J Clin Nutr 52: 1-28.

43. HMSO, UK (1994): Nutritional aspects of cardiovascular disease (report on health and social subjects, 1994. No.46) London: HMSO.
44. Jorjani, S.; Khanipour, A. A. and Ghelichi, A. (2014): Chemical composition and fatty acid profile of common Kilka , Clupeonella cultriventris caspi. Caspian J. Env. Sci. 2014, Vol. 12 No. 1 pp. 119-128.
45. Hajirostamloo, B. and Hajirostamloo, M. (2010): The omega-3 fatty acids content of some Iranian fresh water fish species. Word Journal of Fish and Marine Sciences. 2(4): 285-290.
46. Soetan, K. O.; Olaiya, C. O. and Oyewole, O. E. (2010): The importance of mineral elements for humans, domestic animals and plants: A review. African Journal of Food Science, 4(5): 200-222.
47. Tolonen, M. (1990): Vitamina and minerals in health and nutrition, Ellis Horword, London, pp. 152-188.
48. Judith, K. and Jenny, M. (1987): Proximate composition, energy, fatty acid, sodium and cholesterol content of finfish, shellfish and their products. National Marine Fisheries Service, NOAA.
49. Osborne, D. R. and Voogt, P. (1996): The analysis of nutrients in foods. Food Science and Technology: A Series of Monographs, Academic Press Inc. London LTD, 251.
50. Ako, P. A. and Salihu, S. O. (2004): Studies on some major and Trace metals in smoked and oven dried fish. Journal of Applied Sciences and Environmental Management, Vol. 8, No. 2 dec. pp 5-9.
51. Javaheri Baboli, M. and Velayatzadeh, M. (2013): Determination of heavy metals and trace elements in the muscles of marine shrimp, *fenneropenaeus merguiensis* from Persian gulf, Iran. J. Anim. Plant Sci. 23(3):2013
52. Kumaran, R.; Ravi, V.; Gunalan, B.; Murugan, S. and Sundramanickam, A. (2015): Estimation of proximate, amino acids, fatty acids and mineral composition of mullet (*Mugil cephalus)* of Parangipettai, Southeast Coast of India. Pelagia Research Library, Advances in Applied Science Research, 2012, 3 (4):2015-2019.

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