The Omega-3 Fatty Acids Content of Some Iranian Fresh Water Fish Species

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Abstract: Omega-3 fatty acids are unique long-chain polyunsaturated fatty acids, since these fatty acids occur in high amounts only in sea food, it is necessary to determine their fatty acid composition for recommendation of a suitable preventive diet. In this study, 8 fresh water species (Rutilus fesii kutum, Clupeonella cultiventris caspia, Cyprinus carpio, Sander lucioperca, Salmo salar, Onchorhynxus mykiss, Mugil cephalus and Liza aurata) were investigated. Generally Oleic acid of MUFAs was the dominant fatty acid in species. The highest value of SFAs was seen in Clupeonella cultiventris caspia and Salmo salar had lowest values. There was significant difference among all samples except Rutilus fesii kutum vs. Sander lucioperca and Onchorhynxus mykiss vs. Mugil cephalus. MUFAs value varied from 46.20% for Rutilus fesii kutum to 19.04% for Liza aurata. The amount of MUFAs were similar between Rutilus fesii kutum and Sander lucioperca also Cyprinus carpio, Onchorhynxus mykiss and Mugil cephalus but significantly differ among other samples. PUFAs were considerably higher in Salmo salar in comparison with other species and Clupeonella cultiventris, caspia Cyprinus carpio, Sander lucioperca and Onchorhynxus mykiss had similar amount of these fatty acids. In all species the PUFAs/SFAs ratio was less than 1 except Salmo salar, this ratio among all species was more the recommended minimum value (0.45) excluding Mugil cephalus. The highest EPA was found in Sander lucioperca accounting for 6.10% of its total fatty acids, the high proportion of DHA was found in Salmo salar and its 19.76% of the total fatty acids. The Salmo salar had the highest (25.05%) and Mugil cephalus the lowest (2.42%) EPA+DHA content. The higher concentration of omega-3 and omega-6 PUFAs were found in Salmo salar and Sander lucioperca. The difference between ω-3 unsaturated fatty acids in the samples were significant statistically (P<0.01). The amount of ω-3/ω-6 ratio ranged from 0.51 to 3.94, Mugil cephalus had the lowest and Salmo salar the highest. It has been suggested that a ratio of 1.1 to 1.5 would contribute to a healthy human diet. From all of comparison it was evident that Salmo salar can be considered nutritionally attractive for consumers and successfully used for the care or prevention of cardiovascular diseases.

Key words: Omega-3 • Fatty acids • Fish • Iran

INTRODUCTION

Sea and fresh water fish which constitute majority of water products make up an important part of animal food sources for human. Fish is quite different from the other animal food sources because they provide low energy, high level proteins, a significant amount of polyunsaturated fatty acids and as compared to red meat, fish flesh is easily digestible because it contains long muscle fiber [1]. Recent studies have clearly shown the importance of polyunsaturated fatty acids (PUFAs) nutritional values for human health [2]. The nutritional importance of fish consumption is in great extent associated with the content of polyunsaturated fatty acids, especially omega-3 fatty acids (ω-3 FAs) and omega-6 fatty acids (ω-6 FAs) [3], every living cell needs essential fatty acids like omega-3 and omega-6 but since they cannot be synthesized in human body, they must be obtained through diet [4]. Polyunsaturated fatty acids ω-3 play an important role in reducing the cholesterol level, preventing heart disease and has anti-inflammatory and anti-thrombosis effects [5]. Omega-3 prevents asthma, hypertension, diabetes, cancer, brain aging, Alzheimer and kidney dialysis and tends to inhibit the development or metabolism of these diseases in the body [6].

Omega-3 fatty acids are unique long-chain polyunsaturated fatty acids can be divided in to three main categories: Eicosapentaenoic acid (EPA), Docosahexaenoic acid (DHA) and Alpha-Linolenic acid, out of which EPA and DHA have the most beneficial effects. EPA and DHA are found mainly in fish oils while Alpha-Linolenic is usually derived from plant sources.

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Since these fatty acids occur in high amounts only in sea food, it is necessary to determine their fatty acid composition for recommendation of a suitable preventive diet. In recent years, there have been a large number of experimental studies in the composition of fatty acids in various fish species [2-4, 8-31, 41].

In this study, 8 fresh water species (Rutilus fresii kutum, Clupeonella cintriventris caspia, Cynorhyncus mykiss, Sander lucioperca, Salmo salar, Oncorhyncus mykiss, Mugil cephalus and Liza aurata) generally sold on the Iran fish market were investigated. The main aim of the present study was to obtain information on fatty acids composition with special emphasis on omega-3 fatty acid since it is essential in human nutrition and its importance from medical point of view.

**MATERIAL AND METHOD**

In this study, fishes were obtained from the local market, immediately after collection these fishes were washed and taken into the laboratory, they were identified using FAO manual then stored in the freezer. In an attempt to obtain a homogenous sample from each species, the fishes were gutted, washed, filleted, minced and blended. Ten gram of each homogenized sample were used for fatty acids analysis, lipid was extracted by using chloroform and methanol 2:1 (v/v) [32, 33]. BF₃ and n-hexane were used for the preparation of the fatty acid methylesters (FAME) [34]. The fatty acid methylester of fillets were analyzed by gas chromatography (Philips, UK) equipped with a flame ionization detector (FID). The column used was a capillary (BPX, 60 m length, 0.32 mm diameter, 0.25 μm thickness). The temperature of injection port and the detector were set at 280°, 240°. The column temperature was programmed to increase from 180° to 250°. The sample injected was 3 μL with carrier gases He, H₂ and air 40, 40 and 500 mL/min, respectively. Fatty acid peaks in the samples were identified by comparing the retention times of the samples with that of the standard mixture of FAME (Sigma). The areas of the peaks were measured and the relative amounts of the fatty acids were calculated. Each sample (species) was analyzed 3 times and its average was calculated. The data were presented as Mean ± Standard Deviation (SD) and analysis of variation was used for the statistical analysis using the SPSS software.

**RESULT AND DISCUSSION**

The existing inter species variability in the composition of fatty acids of fish lipids is usually explained by the existence of a large number of external factor: type of aquatic environment, trophic aspects-interaction, type and composition of diet, season of the year, ... and internal factors: fish species, feeding regime and digestion, life cycle stage, growth condition, part of muscle tissue, ... [15, 24, 35]. *Rutilus fresii kutum*, *Clupeonella cintriventris caspia*, *Cynorhyncus mykiss*, *Sander lucioperca*, *Salmo salar*, *Oncorhyncus mykiss*, *Mugil cephalus* and *Liza aurata* are among the species of fresh water fish that are mostly consume in Iran, they are also some of the most valuable fishes due to their omega fatty acids composition. We detected and evaluated a total of 10 fatty acids (C14:0, C16:0, C16:1, C18:0, C18:1, C18:2, C18:3, C20:4, C20:5, C22:6) of the present fishes. Table 1 shows the average values of ŌSE, ŌMUFAs, ŌPUFA, ŌPUFA/ŌSFA, EPA+DHA, Ō-3, Ō-6 and Ō-3/Ō-6 in samples.

The fatty acid composition of the fish species (edible parts) varied. Generally Oleic acid (C18:1) of MUFAs was the dominant fatty acid in species. Among SFAs those occurring in the highest proportion were palmitic (C16:0) and stearic (C18:0). The highest value of SFAs was seen in *Clupeonella cintriventris caspia* and *Salmo salar* had lowest values. There was significant (p<0.01) difference among all samples except *Rutilus fresii kutum* vs. *Sander lucioperca* and *Oncorhyncus mykiss* vs. *Mugil cephalus*. Oleic acid (C18:1) was the main fatty acid among the MUFAs in all fish species. MUFAs value varied from 46.20% for *Rutilus fresii kutum* to 19.04% for *Liza aurata*. The amount of MUFAs were similar between *Rutilus fresii kutum* and *Sander lucioperca* also *Cynorhyncus mykiss* and *Mugil cephalus* but significantly differ among other samples. PUFA were considerably higher in *Salmo salar* in comparison with other samples and *Clupeonella cintriventris*, *Cynorhyncus mykiss*, *Sander lucioperca* and *Oncorhyncus mykiss* had similar amount of these fatty acids. ŌPUFA/ŌSFA showed nutritional values of species, in all species the PUFA/SFA ratio was less than 1 except *Salmo salar*, this ratio among all species was more the recommended minimum value (0.45) excluding *Mugil cephalus* [2, 36].

The highest EPA (C20:5) was found in *Sander lucioperca* accounting for 6.10 % of its total fatty acids, the high proportion of DHA (C22:6) was found in
Table 1: Average of fatty acid values in studied fishes (g/100g lipid)

<table>
<thead>
<tr>
<th>Fish sample</th>
<th>ÔSEFA</th>
<th>ÔMUFA</th>
<th>ÔPUFA</th>
<th>ÔPUFA/ÔSEFA</th>
<th>ÔPA+DHA</th>
<th>Ô-3</th>
<th>Ô-6</th>
<th>Ô-3/Ô-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rutilus frisii kutum</td>
<td>28.16±0.89&lt;sup&gt;a&lt;/sup&gt;</td>
<td>46.20±0.34&lt;sup&gt;a&lt;/sup&gt;</td>
<td>14.55±0.54&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.51±0.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.39±0.54&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.67±0.54&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.97±0.13&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.62±0.13&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Clupeonella cultriventris caspia</td>
<td>36.66±0.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>43.24±0.18&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.37±0.16&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.52±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.11±0.16&lt;sup&gt;a&lt;/sup&gt;</td>
<td>13.66±0.16&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.66±0.18&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.42±0.18&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cypinus carpio</td>
<td>22.47±0.46&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.00±0.17&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.74±0.17&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.86±0.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.95±0.17&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.27±0.17&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.55±0.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.32±0.08&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sander lucioperca</td>
<td>27.73±0.14&lt;sup&gt;a&lt;/sup&gt;</td>
<td>43.91±0.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.36±0.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.69±0.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.46±0.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.34±0.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.39±0.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.76±0.10&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Salmo salar</td>
<td>17.96±0.14&lt;sup&gt;a&lt;/sup&gt;</td>
<td>27.77±0.12&lt;sup&gt;a&lt;/sup&gt;</td>
<td>38.41±0.12&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.13±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>25.05±0.12&lt;sup&gt;a&lt;/sup&gt;</td>
<td>30.60±0.12&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.76±0.14&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.94±0.14&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Oncorhynchus mykiss</td>
<td>25.49±0.19&lt;sup&gt;a&lt;/sup&gt;</td>
<td>24.01±0.11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>18.81±0.11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.73±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.00±0.11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>13.49±0.11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.46±0.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.46±0.08&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mugil cephalus</td>
<td>25.11±0.13&lt;sup&gt;a&lt;/sup&gt;</td>
<td>24.59±0.31&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.68±0.31&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.30±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.42±0.31&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.65±0.31&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.19±0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.51±0.05&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Liza aurata</td>
<td>32.83±0.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.04±0.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>21.98±0.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.66±0.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.74±0.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>14.52±0.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.41±0.11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.96±0.11&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

ÔSEFA: (C14:0, C16:0, C18:0)
ÔMUFA: (C16:1, C18:1)
ÔPUFA: (C18:2, C18:3, C20:4, C20:5, C22:6)
Ô-3: (C18:3, C20:5, C22:6)
Ô-6: (C18:2, C20:4)

Means ± SD with different letters in the same column are significant at P<0.01.

Fig. 1: Comparison of omega-3 and omega-6 values of samples (Different letters in the same column are significant at P<0.01) g/4

Salmo salar and its 19.76% of the total fatty acids. The Salmo salar had the highest (25.05%) and Mugil cephalus the lowest (2.42%) EPA+DHA content. The significance of EPA+DHA which are crucial both for fish and human health spring for the fact that EPA is the most important essential fatty acid of Ô-3 series in human diet because it is the precursor to the Ô-series eicosanoids and play a role in protecting cardiovascular health and it is responsible for regulating activities concerning the lipid metabolism in plasma [37]. In human it is reported that DHA decrease the concentration of low density lipoprotein cholesterol in plasma and has been recognized affective in regulating blood pressure, stimulating nerves and reducing the risk of cholesterol by decreasing the level of triglyceride [38]. EPA+DHA play a vital role in the development and functioning of the nervous system (brain), photoreception (vision) and the reproductive system [2]. The level of EPA+DHA is important in human diet and health. The higher concentration of omega-3 and omega-6 PUFAs were found in Salmo salar and Sander lucioperca (Fig. 1). The difference between Ô-3 unsaturated fatty acids in the samples were significant statistically (P<0.01). According to a variety of authors, fresh water fish contain shows higher concentration of Arachidonic and Linoleic acids. This may be due to a dietary effect and saturation and/or elongation mechanisms [39, 40]. It has shown higher concentration of EPA and DHA in planktivore fishes and
Linoleic acid in carnivores (feeds on benthic organism like insect larvae, crustacean...) [26]. The proportion of ω-3/ω-6 has been suggested to be a safe indicator to compare the nutritional values of the fish fat [25]. For the well-being of human health, the consumption of fish and fish products rich in ω-3 PUFAs and poor in ω-6 PUFAs is essential [41]. The low proportion of ω-3/ω-6 PUFA increases the pathogens of numerous diseases such cardiovascular diseases and inflammations [42]. Enzyme activity and chain prolongation which enable desaturation reduces ω-3 PUFAs and increases ω-6 PUFAs have been seen in fresh water fish. This is the reason behind the low proportion ω-3/ω-6 in fresh water fishes [21]. The amount of this ratio ranged from 0.51 to 3.94, Mugil cephalus had the lowest and Salmo salar the highest. It has been suggested that a ratio of 1:1 to 1.5 would contribute to a healthy human diet [25] and WHO recommendation is the daily ratio ω-3/ω-6 in total human diet should be no less than 1.5 [43].

From all of comparison it was evident that Salmo salar can be considered nutritionally attractive for consumers and successfully used for the care or prevention of cardiovascular diseases.

Our Results Are in Agreement from Different Aspects with Previous Study: Pirestani et al. [2] evaluated a total of 12 fatty acids and reported the OSA, OMUFA, ÓPUFA values and ω-3/ω-6 ratio for Rutilus frisii kutum (28.99, 56.25, 14.76 and 4.54), Liza aurata (41.06, 44.72, 14.22 and 4.72), Cynopterus carpio (36.04, 48.21, 15.75 and 3.35), Sander lucioperca (35.99, 40.99, 23.03 and 2.10) and Clupeonella cultriventris caspia (36.88, 43.68, 19.43 and 6.60).

Hedayatifard and Jamali [8] detected 10 fatty acids in pike perch (Sander lucioperca) and show that the total monounsaturated fatty acids content of it was 43.95%, total polyunsaturated fatty acids content was 19.68%, omega-3 series and omega-6 series were 8.46 and 11.22%. In other experiment Hedayatifard et al. [23] studied Liza aurata and obtain its total saturated fatty acids content 37.03%, total polyunsaturated and monounsaturated fatty acids 22.07 and 19.23%. The amount of omega-3 fatty acids of Liza aurata calculated about 14.68% while its omega-3 fatty acids were 7.45%.

De Castro et al. [11] that studied fatty acid composition of common carp (Cynopterus carpio), find high content of monounsaturated fatty acids (about 50%) and distinguish the Oleic acid (C18:1) was the dominant fatty acid in this species.

Sengupta et al. [20] studied Mugil cephalus and calculated fatty acids quantity of its fillet. Their result show that SFAs, MUFAs, PUFAs, ω-3 and ω-6 values were 25.30, 24.70, 7.80, 2.60 and 5.20.

Similar values was calculated by Exler [31] for Salmo salar (18.10, 27.8, 38.5, 30.70 and 7.80, respectively) and Oncorhynchus mykiss (25.71, 25.05, 19.04, 13.45 and 5.59, respectively).

This research work provided useful data about fatty acid composition (especially omega-3 essential fatty acids) of Iranian fresh water fishes and opened new avenues for further research in this field for the benefits of human being.

REFERENCES


