TÜBİTAK

Turkish Journal of Veterinary and Animal Sciences

http://journals.tubitak.gov.tr/veterinary/

Research Article

Turk J Vet Anim Sci
(2014) 38: 445-451
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doi:10.3906/vet-1301-15

Proximate composition and mineral and fatty acid profiles of male and female jinga shrimps (*Metapenaeus affinis*, H. Milne Edwards, 1837)

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Received: 06.01.2013 • **Accepted:** 29.04.2014 • **Published Online:** 17.06.2014 • **Printed:** 16.07.2014

Abstract: The jinga shrimp (*Metapenaeus affinis*, H. Milne Edwards, 1837) is a commercially valuable alien decapod and a seafood product that is highly popular at seafood restaurants in İzmir (Turkey). The chemical, mineral, and fatty acid compositions of male and female jinga shrimps harvested in the Mediterranean Sea were determined for the first time. The compositions of both sexes confirmed that the jinga shrimp is a healthy food source due to its balance of nutrients, with efficient levels of protein and mineral contents. In fatty acid composition, the saturated fatty acid fraction was dominant, followed by polyunsaturated fatty acid and monounsaturated fatty acid. The atherogenic and thrombogenic index values were found to be higher in the jinga shrimp compared to other food sources, such as lamb, pork, or chicken.

Key words: Jinga shrimp, alien species, mineral content, EPA, DHA

1. Introduction

Shrimp is a commercially important seafood product that has an increasing exportation rate in the Turkish seafood market, contributing to the national economy. Apart from being a delicacy, crustacean species including shrimp, crab, and lobster contain amino acids, peptides, proteins, and other useful nutrients (1). Shrimp is an extremely good source of protein and is very low in fat and calories, making it a healthy food choice for consumers. In addition, shrimp flesh consists of highly unsaturated fatty acids (FAs), such as eicosapentaenoic (C20:5n-3, EPA) and docosahexaenoic (C22:6n-3, DHA) acids, which are essential in the human diet (2). Penaeid shrimp has recently gained commercial importance in İzmir due to the increased values in export sales and the tourist appeal of fish restaurants in İzmir.

The jinga shrimp (*Metapenaeus affinis*) was brought from the Indo-West Pacific region by freighters traveling to the Mediterranean Sea. The jinga shrimp has a vital commercial value in the Indo–West Pacific, which is located between the Arabian Gulf and the Malay Archipelago (3). For the first time, specimens of *M. affinis* were collected from the Mediterranean Sea from the inner site of the İzmir Bay in 2008 (4). Due to their increased commercial value and a longer permitted fishing season than the native bay prawn (*Melicertus kerathurus*), local fishermen have begun to exploit them (5).

The compositions of jinga shrimp may change depending on the diet, location, and condition (maturity stages of the female). The sex of the animal may also affect its fatty acid content. Furthermore, the proximate composition (6), FA profile, cholesterol (7), and total carotenoid contents (8) of the jinga shrimp may change seasonally.

The jinga shrimp was preferred by consumers, replacing *M. kerathurus* (caramote prawn) in İzmir Bay due to its flavor and reasonable price. However, information regarding the chemical composition and FA content of this species is limited. The goal of this study was to compare the chemical compositions, the mineral contents, and finally the FA contents of the male and female jinga shrimps in the Mediterranean Sea.

2. Materials and methods

2.1. Animals

Jinga shrimps were caught by a commercial shrimp-fishing vessel in the middle of İzmir Bay (Aegean coast of Turkey) during the 2012 fishing season (July). A total of 100 specimens (50 male, 50 female) were obtained equally from each size group, and all the jinga shrimps were sorted according to sex by checking the external genital organs. They were placed in polystyrene boxes and covered with ice to keep them cool on the fishing vessel. Boxes were stored at +4 °C immediately after the vessel arrived at the

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port (about 5 h after catching) and later transported to the laboratory. The jinga shrimps and ice were taken out of the boxes and placed on trays. Initially, the weight and other measurements of the jinga shrimps were recorded. The carapace length of each jinga shrimp was recorded as the distance from the postorbital margin to the middorsal posterior edge of the carapace using digital calipers with a precision of 0.1 mm. The wet weight of each jinga shrimp was also recorded using a digital balance with a precision of 0.01 g. Later, heads, shells, and intestines were manually segregated using a toothpick. Samples of the jinga shrimps were pooled and homogenized for proximate composition analysis. Ten specimens of each sex were allocated for mineral composition and FA profile analyses. Finally, the samples of jinga shrimps were transferred to the Argefar laboratory for mineral composition and FA profile analyses.

2.2. Chemical analysis

Lipid content of each jinga shrimp was measured using the method of Bligh and Dyer (9). Ludorf and Meyer's (10) method was used to measure ash and moisture contents and protein content was determined by the Kjeldahl procedure using the AOAC method (11). The carbohydrate content of the samples was determined as difference from the total percentage (100%).

2.3. Mineral composition

The mineral composition was determined by using ICP-MS. USEPA method 3051A protocol (12) was employed to digest the sample material, using microwave-assisted HNO_3 digestion. Each sample (0.003 g) was weighed into a microwaveable flask, and 3 mL of nitric acid was added and digested by heating in a microwave. The parameters of the microwave were as follows: maximum power, 1200 W; ramp, 15.00 min; hold, 10.00 min; maximum temperature, 200 °C. The samples were cooled and made up to a volume of 30 mL before the analysis, and the mineral elements were measured using ICP-MS. The mineral composition was determined in triplicate using an ion chromatography (Agilent 7500CE, Santa Clara, CA, USA) (13).

2.4. Sample preparation for fatty acid analysis

Ten milligrams of extracted oil was dissolved in 2 mL of KOH followed by the addition of 2 mL of isooctane. The tubes were vortexed for 2 min after each step and centrifuged for 10 min at 4000 rpm. The bottom layer was removed and injected to the GC-FID system (14).

2.5. Gas chromatograph conditions

Fatty acid methyl esters (FAME) were obtained on an HP-Agilent 6890 (Santa Clara, CA, USA) model gas chromatographer (GC) equipped with a flame ionization detector and fitted with a SUPELCO SP 2560 capillary column (100 m, 0.25 mm i.d., 0.25 μm). The oven temperature was set at 140 °C for 5 min and later it was increased by 4 °C per min up to 240 °C, where it was maintained for 20 min, whereas the injector and detector temperatures were set at 250 and 260 °C, respectively. The carrier gas was helium (with a linear velocity of 1 mL/min and injection volume of 1 μL). The flow rate of hydrogen was 35 mL/min and of compressed air was 350 mL/min. The FAs were identified by comparing their retention times to those of a standard mixture of FAs (Supelco 37 component FAME mixture). The GC analyses were performed in triplicate, and the results were expressed as % of total FAME area as the mean value of a percentage.

According to the Ulbricht and Southgate equations (15), the atherogenic and thrombogenic indices (AI and TI, respectively) were calculated to measure the risk of jinga shrimp to the incidence of coronary heart disease.

$$AI = \frac{[\,(12:0+4)\times(14:\ 0+16:0)]}{[\,\Sigma\,\text{MUFA}+\Sigma\,\text{PUFA}\,(n-6)+(n-3)]}$$

$$TI = \frac{[(14:0+16:0+18:0)]}{\begin{array}{c}[(0.5\times\Sigma\,\text{MUFA})+(0.5\times\Sigma\,\text{PUFA}\,(\,n-6))+\\(3\times\Sigma\,\text{PUFA}\,(n-3))+(n-3\,/\,n-6)]\end{array}}$$

2.6. Statistical analysis

All data obtained from the samples were subjected to an independent sample t-test (SPSS 16.0), at a confidence level of 95%. The test was selected to compare 2 independent jinga shrimp sample groups (male and female jinga shrimps) to estimate the difference in recorded data. The results are presented as means ± SD with the significance level set at $P < 0.05$ under varying sexes.

3. Results

3.1. Proximate composition

The proximate compositions of male and female jinga shrimps harvested in İzmir Bay are presented in Table 1. The mean total length/weight results of the male and female samples were as follows: 24.45 ± 1.25 cm/9.85 ± 1.11 g (male), 33.20 ± 2.35 cm/19.57 ± 3.03 g (female). No significant difference was found in the moisture and protein contents of male and female samples. However, both the moisture and protein values were lower in the female samples. A significant difference between the male and female samples was predicted, but the fat content was similar, and no significant difference was observed ($P > 0.05$). On the other hand, the carbohydrate content was significantly higher in female samples compared to male samples ($P < 0.05$). In particular, the ash values appeared to be related to the size of the shrimp and the ash values were significantly different between male and female jinga shrimps.

3.2. Mineral content results

The mineral contents of male and female samples are reported in Table 2. The sexes of jinga shrimps were compared to determine the Na, K, Ca, Mg, Zn, Cu, Fe,

Table 1. Proximate composition values of male and female jinga shrimps (%).

Sex	Moisture	Crude Protein	Crude fat	Ash	Carbohydrate
Male	78.43 ± 0.98[a]	19.1 ± 1.06[a]	1.07 ± 0.12[a]	1.10 ± 0.13[a]	0.30 ± 0.05[a]
Female	77.47 ± 0.35[a]	18.4 ± 0.75[a]	1.30 ± 0.53[a]	1.86 ± 0.08[b]	0.96 ± 0.20[b]

Data are expressed as mean ± SD (n = 3).
Different superscript letters in the same column indicate significant differences ($P < 0.05$).

Table 2. Mineral composition of the whole body of male and female jinga shrimps.

Mineral content (mg/kg)	Male	Female
Sodium	1253.50 ± 26.50[a]	1252.50 ± 12.50[a]
Potassium	3031.00 ± 13.0[a]	3558.50 ± 12.50[b]
Calcium	245.00 ± 2.30[a]	236.55 ± 0.65[b]
Magnesium	372.10 ± 9.20[a]	414.00 ± 9.00[b]
Zinc	9.71 ± 0.09[a]	9.72 ± 0.24[a]
Copper	4.09 ± 0.10[a]	4.22 ± 0.12[a]
Iron	0.87 ± 0.01[a]	1.37 ± 0.0[b]
Cobalt	ND	ND
Manganese	0.10 ± 0.0[a]	0.15 ± 0.01[a]
Chromium	ND	ND
Aluminum	0.58 ± 0.02[a]	0.70 ± 0.01[b]
Tin	ND	ND
Nickel	0.04 ± 0.0[a]	0.05 ± 0.03[a]
Selenium	ND	ND

Data are expressed as mean ± SD (n = 3).
Different superscript letters in the same row indicate significant differences ($P < 0.05$).
ND = not detected.

Co, Mn, Cr, Al, Sn, Ni, and Se contents in their muscles. No significant difference was found in the Na content for either sex (1253.50 ± 26.50 mg/kg and 1252.50 ± 12.50 mg/kg). Significant differences were found in the K, Ca, and Mg values ($P < 0.05$). The Ca content of female samples was lower compared to the male samples, while higher K and Mg values were found in female samples. The values of Ca, K, P, Na, and Fe were as follows: 591 mg/kg, 2188 mg/kg, 1666 mg/kg, 1471 mg/kg, and 16.3 mg/kg, respectively. Heavy metals, Co, Cr, and Se were not detected in either sex. However, the Fe, Mn, and Al levels were higher in female samples and no significant difference was found in the Ni content ($P > 0.05$). The levels of essential microelements (Zn, Mn, Cu) were sufficient in *M. affinis*. In addition, values of the nonessential microelements, Al and Ni, were 0.58–0.70 mg/kg and 0.04–0.05 mg/kg for males and females, respectively.

3.3. FA composition results

The FA compositions of male and female jinga shrimps are reported in Table 3. The jinga shrimp is rich in n-3 FAs. The FA composition of male and female samples ranged as follows: total saturated fatty acids (SFA) content of male shrimp was 53.64%, while the total SFA content of female shrimp was 60.31%. The total monosaturated fatty acids (MUFAs) contents of male and female shrimps were 15.47% and 19.90%, respectively. The total polyunsaturated

Table 3. Fatty acid profile of the whole body of male and female jinga shrimps.

Fatty acids (%)	Male samples (%)	Female samples (%)
C10:0	0.72 ± 0.05	0.00 ± 0
C14:0	1.96 ± 0.12[a]	1.47 ± 0.17[b]
C16:0	23.24 ± 0.14[a]	23.70 ± 1.02[a]
C17:0	2.24 ± 0.04[a]	1.39 ± 0.02[b]
C18:0	20.05 ± 0.1[a]	18.08 ± 0.57[b]
C20:0	0.57 ± 0.01[a]	0.48 ± 0.04[b]
C22:0	5.99 ± 0.14[a]	3.76 ± 0.12[b]
C23:0	5.55 ± 0.1[a]	4.76±0.23[b]
SFA	**60.31**	**53.64**
C14:1	1.20 ± 0.08[a]	0.63 ± 0.07[b]
C16:1	2.73 ± 0.13[a]	6.04 ± 0.1[b]
C17:1	0.87 ± 0.02[a]	0.74 ± 0.07[b]
C18:1n-9t	0.00 ± 0	0.29 ± 0.03
C18:1n-9c	7.53 ± 1.05[a]	9.78 ± 0.75[b]
C20:1	0.74 ± 0.08[a]	0.81 ± 0.05[b]
C22:1n-9	0.95 ± 0.02[a]	0.60 ± 0.04[b]
C24:1	1.45 ± 0.26[a]	1.01 ± 0.13[b]
MUFA	**15.47**	**19.90**
C18:2n-6t	0.00 ± 0	0.00 ± 0
C18:2n-6c	1.62 ± 0.07[a]	1.56 ± 0.08[b]
C18:3n-6	0.00 ± 0	0.56 ± 0.1[a]
C20:2	1.14 ± 0.1[a]	0.72 ± 0.15[b]
C22:2	0.00 ± 0	0.43 ± 0.01[b]
C20:5n-3	12.71 ± 0.85[a]	14.38 ± 0.76[a]
C22:6n-3	8.73 ± 0.42[a]	7.84 ± 0.34[b]
PUFA	24.21	25.48
PUFA/SFA	0.40	0.48
Σn-6	1.62	2.11
Σn-3	21.45	22.22
DHA/EPA	0.68	0.54
AI	2.62	2.27
TI	0.52	0.49

Data are expressed as mean ± SD (n = 3).
Different superscript letters in the same row indicate significant differences ($P < 0.05$).
Atherogenic index value (AI).
Thrombogenic index value (TI).

fatty acids (PUFAs) contents of male and female shrimps were 24.21% and 25.48%, respectively. The percentages of MUFAs and PUFAs were higher in female samples compared to male samples. The highest determined proportion of FAs in the male and female samples, reported in Table 3, was found as palmitic acid (16:0, 23.24% and 23.70%, respectively), followed by stearic acid (18:0, 20.05% and 18.08%, respectively), EPA (20:5n-3, 12.71% and 14.38%, respectively), DHA (22:6n-3, 8.73% and 7.84%, respectively), and tricosanoic acid (23:0, 5.55% and 4.76%, respectively). The SFA fraction was dominant (60.31% males and 53.64% females), followed by the PUFA (24.21% males and 25.48% females) and the MUFA (15.47% males and 19.90% females).

4. Discussion

The protein and fat values were lower compared to the findings of Rosa and Nunes (16) about the edible part of 3 crustacean species: the red shrimp (*Aristeus antennatus*), pink shrimp (*Parapenaeus longirostris*), and Norway lobster (*Nephrops norvegicus*). A higher level of fat was found in different species caught in the Lagos lagoon in Nigeria and in Indian white shrimp (*Penaeus indicus*) caught off the southeastern coast in India (17). Higher values of crude fat contents were also found in the pond-cultured shrimp *Penaeus monodon* (6.3% DM) and *Penaeus vannamei* (5.7% DM), as reported by Sriket et al. (18). The carbohydrate content was significantly higher in female samples compared to male samples ($P < 0.05$). In particular, the ash values were significantly different between female and male jinga shrimps due to their size. The females were all larger than the male specimens; thus the ash content was determined to be higher in female samples. A corresponding result for female shrimp was also found in white shrimp (19). The chemical compositions of both sexes confirmed that the jinga shrimp is an excellent food source due to its balance of nutrients and protein content.

Yanar and Celik (20) investigated the Ca, K, P, and Na mineral contents of the speckled shrimp (*Metapenaeus monoceros*) in different seasons. As all microelement levels were compared, only the K level was found to be higher compared to Yanar and Çelik's study (20). For penaeid and pandalid shrimps, these values were lower compared to the study by Exler (21). Karakoltsidis et al. (6) reported nearly one-fifth of the Ca content (1210 mg/kg) in *Aristeus antennatus*. Adeyeye et al. (22), reported higher Ca content in another shrimp, *Penaeus notobulis*; nevertheless, he reported a Mg content similar to the Mg content in the jinga shrimp.

Kryznowek and Murphy (23) reported similar fatty acid composition results on the jinga shrimp. The SFA content of the jinga shrimp was higher compared to the Alaskan pink shrimp *Pandalus borealis* with 22.4% (24). Additionally, higher values of EPA and DHA were determined in both sexes of the jinga shrimp compared to *Parapenaeus longristris* and *Panaeus semisulcatus* (25). The recommended minimum PUFA/SFA ratio is 0.45 (26). This ratio for the male samples was lower (0.40), but in female samples the ratio was above the minimum (0.48). All the SFAs of male samples were significantly higher, whereas the primary MUFAs of male samples (18:1n-9c and 16:1) were lower compared to the female samples. The lower percentages of linoleic acid (LA, C18:2n-6), a typical plant FA, can be related to the omnivorous habits of the shrimp and the origin of the species. Among the most valuable FAs, EPA and DHA play important roles in the prevention of inflammatory and cardiovascular diseases due to their serum triglycerides-lowering effects. The EPA and DHA contents were relatively adequate in the samples, despite lower values of male samples. Bono et al. (27) reported an inverse correlation in long chain FAs between shrimp sexes and they found lower EPA and DHA contents in the female giant red shrimp (*Aristaeomorpha foliacea*), compared to the male giant red shrimp (*Aristaeomorpha foliacea*). In our study, the DHA content of female samples was lower compared to male samples. The EPA content of the male samples was lower compared to female samples. The DHA and EPA results of jinga shrimps were similar to the results of Huang et al. (28), which ranged from 11.5% to 13.7% FA, for farmed white shrimp (*Penaeus vannamei*). In addition, they found higher DHA content compared to the jinga shrimps, ranging from 8.9% to 10.4% FA. Yanar and Çelik (29) found a lower EPA content in *Penaeus semisulcatus* (7.7%–12.5% FA) and *Metapenaeus monoceros* (8.3%–12.6% FA) harvested off the eastern coasts of Turkey in different seasons. A similar proportion of DHA was also found in these 2 shrimp species: *Penaeus semisulcatus* (5.1%–12.2% FA) and *Metapenaeus monoceros* (5.3%–10.1% FA). Bottino et al. (30) compared 3 species of shrimp, *Penaeus setiferus*, *P. aztecus*, and *P. duorarum*, caught in the Gulf of Mexico, and reported that EPA and DHA values ranged from 12.5% to 16.9% FA and from 7.2% to 12.2% FA, respectively. Moreover, FA profiles in 5 species of Indian prawns (*Metapenaeus monoceros*, *M. dobsoni*, *M. affinis*, *Penaeus indicus*, and *Parapenaeopsis stylifera*) have lower levels of EPA and similar levels of DHA compared to the present study, with values ranging from 0.5% to 2.0% FA and from 6.2% to 14.7% FA, respectively.

Ulbricht and Southgate (15) proposed an AI for the composition of a fat based on current information about the effect of various FAs on serum cholesterol and low and high density lipoprotein concentrations. Based on this equation, only SFAs with chain lengths of 12 to 16 C atoms are atherogenic, and myristic acid is considered

to be 4 times more atherogenic compared to the other 2 SFAs. All unsaturated FAs, regardless of their double bond number, position, or configuration are considered equally effective in decreasing atherogenicity, due to a lack of reliable information to assign more suitable coefficients to the various structures. High values of the index reflect the possibility of cardiovascular pathologies occurring as a result of atherogenic lipid intake. When applied to various fats and oils, this equation gives AI values of 13–20 for coconut oil, 7 for palm kernel oil, 0.7 for cocoa butter, and <0.5 for other vegetable oils. For milk, butter, and cheese, the AI and TI values are higher than 2.0, while for meat, the AI values range from 0.7 to 1.0, and the TI values are between 0.8 and 1.6 (14). The AI values of the female samples were lower compared to the male samples (Table 3). Nevertheless, all recorded values were higher for the jinga shrimp compared to the other animal foods, such as lamb (1.00), beef (0.72), pork (0.69), chicken (0.50), and thornback ray fish (2.37), as well as finned fish (e.g., mackerel 0.28). Similar results were obtained for the TI. Rosa and Nunes (16) reported lower results in different shrimp species compared to the terrestrial animals and their results were similar to the mackerel values. AI values of *M. affinis* were nearly 2 and a half times higher than those of lamb and closer to those of the thornback ray since the jinga shrimp had a higher fat content and different nutritional habits compared to other shrimp species.

In conclusion, from a nutritional point of view, both male and female jinga shrimps demonstrated acceptable quality; in particular, the female jinga shrimps had the highest levels of PUFAs, and the SFA content of the jinga shrimp was higher compared to the other species. Consumers may receive some health benefits consuming the jinga shrimp due to its proximate, mineral, and FA contents. However, consumers who suffer from coronary illnesses should be cautious about the jinga shrimp due to its high SFA content.

Further investigations in other potential locations for the jinga shrimp in the Mediterranean are required to obtain more information about this species. A detailed investigation into the effect of cooking the jinga shrimp is necessary to improve the information regarding FA composition.

Acknowledgments
The authors are grateful to ARGEFAR (Ege University) laboratory team for their technical support.

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