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Comparative study on the nutritional value of some penaeid shrimps from the Western Mediterranean coast of Egypt

Nesreen K. Ibrahim [1,*]

[1] Department of Marine Sciences, Suez Canal University, Ismailia, 41522, Egypt

***Corresponding author:** kadry1339@yahoo.com

ABSTRACT

The present study highlights the nutritional value of three commercial shrimps; the green tiger prawn *Penaeus semisulcatus* (De Haan, 1844), the kuruma prawn *Penaeus (Marsupenaeus) japonicus* (Bate, 1888) and the ginger prawn *Metapenaeus monoceros*. (Fabricus, 1798) collected along the western Mediterranean coast of Egypt. The results show that the percentage of protein of the three studied shrimps was the main constituent where female and male *Marsupenaeus japonicus* had the greatest protein percentage (51.37% and 50.12%, respectively). The highest lipid value was documented in female *Marsupenaeus japonicus* (13.01%) while the highest carbohydrate percentage was recorded in male *Penaeus semisulcatus* (3.1%). Nine essential amino acids which are arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine and valine were identified. Arginine recorded the highest average concentration. Three non-essential amino acids were detected, that are aspartic acid, glutamic acid and glycine. Vitamins B1 and B2 were detected in both sexes. Analysis of minerals showed the presence of four minerals (Ca, K, Na and P). P recorded the highest mineral concentrations in *Marsupenaeus japonicus*, *Metapenaeus monoceros and Penaeus semisulcatus*. Concerning the results of this study that focused on the nutritional value of three commercially important shrimps, it is recommended to be consumed by human as a good source of protein, arginine, vitamins B1 and B2, phosphorus and calcium. In conclusion, this comparative study revealed that the kuruma prawn *Marsupenaeus japonicus* has the best nutritive value among the studied shrimps.

Key Words:

Comparative study, Nutritional value, Amino acids, Penaeid shrimps, Western Mediterranean Sea,Egypt

1. INTRODUCTION

Seafood, especially shrimp is an important source of food for a large sector of the world population. It has a good taste and flavor. Also, it is preferred as tasty food for human being, also it is considered as a good source of national income because of their high prices and demanding on the markets. The edible parts have large amount of protein and small content of fats [1]. Moreover, they are considered as good sources of vitamin-B12 and minerals such as Iron, Selenium and Calcium [2, 3, and 4].

The biochemical structure of any marine organism such as protein, lipid, carbohydrate, vitamins and minerals is important to evaluate its nutritive value. Nutritional composition is important to provide a basis for resource improvement and genetic development [5]. Protein is necessary for normal growth, body tissues maintenance and assessment of physiological values [6]. Quantities of protein differ within species, size, sex and season in body flesh of koi fish collected from Bangladesh [7]. The assessment of protein is revealed upon its amino acids concentration that is the building blocks of proteins. Different conditions such as salinity and environmental situations affect the nutritional composition and quality of marine organisms [8, 9].

The Mediterranean coast of Egypt endowed with rich shrimp resources; predominantly members of the family Penaeidae which are now one of the most exploited components of local marine fauna in Egypt.

However, data available on the biochemical composition of commercial shrimps collected along the Egyptian coast is limited. Thus, this article highlights the nutritive value (protein, lipids, carbohydrates, amino acids, vitamins and minerals) of three penaeid shrimps. These shrimps have commercial importance and are widely favored in the Egyptian local markets. Two species belong to the genus *Penaeus,* the green tiger prawn (*Penaeus semisulcatus* (De Haan, 1844) and the kuruma prawn *Penaeus (Marsupenaeus) japonicus* (Bate, 1888). One species from genus *Metapenaeus,* which is the ginger prawn *Metapenaeus monoceros*. (Fabricus, 1798) collected from the western Mediterranean Sea.

2. MATERIALS AND METHODS

2.1 Samples collection:

Samples were collected directly from fishermen using trawling nets, at the landing site of the western Egyptian Mediterranean coast between Alexandria and El-Sallum (Fig. 1). A total of 10 specimens of each shrimps species (*Penaeus semisulcatus, Marsupenaeus japonicus* and *Metapenaeus monoceros*) were collected during the summer from June 2021 to August 2021. Samples belong to phylum Arthropoda, sub-phylum Crustacea, class Malacostraca, order Decapoda and family Penaeidae. Samples were splashed with deionized water to get rid of any adhering contaminations, and then drained using filter paper. Then they were placed in ice boxes and carried to the laboratory for analysis.

2.2 Processing of samples:

Shrimps were identified based on the morphological characteristics [10]. The washed samples were enclosed in aluminum foil and freeze at -4 °C to facilitate the process of peeling and after that, they were defrosted to get the muscle tissue of both sexes.

2.3 Biochemical analysis:

After thawing the samples, the shell was detached by using a scissor from the abdominal region up to the 5th thoracic segment. The muscle weight was noted for each sample. Moisture of specimens was detected by calculating the difference in tissue weight, before and after drying in an oven at 105 °C until constant weight is reached [11].

1. Total protein was estimated by the Folin phenol method with the standard bovine serum albumin. One gram of wet muscle was homogenized with 10 ml of 0.1 M Phosphate buffer. At room temperature, add 1 ml of homogenate tissue to 0.1 N NaOH and keep it for 30 minutes. Then, add 8ml of distilled water and centrifuge at 4000 rpm for 30 minutes. Take only 0.1 ml of the supernatant and add 0.9 ml of distilled water to reach 1 ml volume. Add 5 ml of alkaline reagent (2 g Na2CO3 in 0.1 N NaOH: 4% Na-K Tartarate 2% CuSO4, 200:1:1) and leave it for 30 minutes at room temperature, then add 0.5 ml of Folin phenol reagent. The color intensity was measured at 750 nm against reagent blank. Caloric values were determined by using conversion factors of Prosser and Brown, (1961).

2. Carbohydrates were determined by dissolving two grams of anthrone in one liter of 95% H2SO4, 5 ml of the solution was taken and 8- 10 ml of the reagent added. The solutions are mixed and the color varies with the amount of carbohydrates.

3. Total lipids were analyzed by taking one gram of the wet muscle in clean test tubes then homogenized in 10 ml chloroform : methanol mixture (2:1) and centrifuged at 4000 rpm for twenty minutes . After centrifugation, 0.5 ml of supernatant was taken and placed in boiling water for 10 minutes. Put the tube in cold water for five minutes. Take 0.1 ml of mixture and add five ml of Phospho-vanillin reagent and incubate the reagent for 15 minutes at 37º C. The absorbance was read at 540 nm against blank on spectrophotometer.

4. Amino acids were estimated by (HPLC) high performance liquid chromatography Beckman 6300 amino acid analyzer, using the official methods of analysis of [11]. The muscles were dried at 80^{o}C for three hours and digested with six ml of hydrochloric acid then dried under vacuum. The powder was dissolved in distilled water and 5 µl of sample was placed on 8 mm thick Silica gel. The plate was placed in butane-Ammonia-Pyridine-Water (3.9:1:3.4:2.6). After that, the plate was sprayed with ninhydrin reagent. The developed plate was documented using photo-documentation chamber (CAMAG-REPROSTAR 3) at UV 254 nm and UV366 nm lights and the plate was scanned at 500 nm. The peak area of the sample was compared with standard amino-acids and quantified.

The contents of vitamins B1 (Thiamin) and B2 (Riboflavin) were studied using high performance liquid chromatography (HPLC), the varian 940-LC [12].

Analyses of 4 minerals (Calcium Ca, Potassium K, Sodium Na and Phophorus P) were examined by Perkin Elmer Atomic (800) using flow injection analysis system (FIAS). Then, samples were weighed (2g wet weight) and left for 12 hours after adding 20 ml of concentrated nitric-acid. A mixture of 0.5 ml of concentrated sulfuric acid and 5 ml of concentrated perchloric acid were added to the samples and then heated until no white smoke was produced. Finally, 2% of hydrochloric acid was added and analyzed using atomic absorption spectrophotometer was analyzed by [11].

2.4 Statistical analysis

Data of the present study was expressed as mean values and standard deviations (M ± SD). Univariate of analysis of variance (two-way ANOVA) was performed to determine whether the parameters vary significantly among the different species and different sexes of each. Differences between male and female of the same species were tested using t-test (Tukey’s) where the term significant difference was referred to $P > 0.05$ [12]. The analysis was carried out using SPSS version 22.0.

Fig (1): Map of the western Mediterranean Sea showing the sampling site.

3. RESULTS AND DISCUSSION

3.1 Biochemical component analysis

In the present study, three edible shrimps were selected because of their economic importance, spreading and invading activities in the studied region. Results displays an average percentage of moisture content ranging from 75.43% in female *P. semisulcatus* and 71.22% in female *M. monoceros* (Fig. 2). This range is compatible with the study of moisture [13] on the tiger prawn *Penaeus monodon* taken from tanks in Malaysia. Also, the data is agreed with that recorded in the Green Tiger Prawn, *Penaeus semisulcatus* from Alexandria markets [14]. Generally, the moisture content of marine organisms is controlled by the types and quality of their food composition [15]. Significant difference in percentage of moisture was only found between the two sexes of *M. monoceros* while no significant differences between sexes in the other two examined shrimps at $P > 0.05$ (Table 1).

Protein was the major biochemical component in all studied shrimps. The maximum parentage value of protein was noticed in females and males of *M. japonicus* (51.37% and 50.12%, respectively) whereas males of *P. semisulcatus* recorded the minimum concentration of protein (38.45%) (Fig.2). No significant differences were recorded in protein content between sexes of the same shrimp species at $P > 0.05$ (Table 1). This result agreed with other studies which stated that protein is the principal biochemical component of crustacean's species [16, 17 and 14]. This result could be referred to the omnivorous feeding habit of shrimps and their diet which contain high protein content such as fishes, mollusks, other crustaceans, algae and some diatoms [18]. Similar results were also found by [19] who studies the nutritional composition of *P. notialis* and *P. monodon* from Nigeria. The protein percentage value was confirmed by [14] who studied *P. semisulcatus* collected from Mediterranean Sea. [20] stated that the higher protein content in males' crustaceans compared to females may be due to the rapid growth rate in males. Generally, the high protein content in the edible parts of shrimps qualifies their high nutritive value.

Moreover, Carbohydrate constituted only a minimum percentage of total biochemical composition and the male of *P. semisulcatus* had the maximum value of carbohydrates (3.1%) (Fig.2). This result was agreed with [21] who studied the biochemical contents in the stomatopod *Oratoasquilla nepa.* This result is similar to that studied by [1, 14] who recorded that carbohydrates have the smallest value in biochemical constituents. Statistical analysis showed no significant differences between sexes of the same species at $P > 0.05$ (Table 1).

Lipids in crustaceans are the vital organic source of metabolic energy and also important in keep up health and development [22]. Generally, they act as main food reserve as protein and are affected by some environmental conditions like temperature [14]. Lipids revealed more or less similar percentages in muscles of both sexes of each species. The highest percentage value of lipid was recorded in females and males of *M. japonicus* (13.01% and 12. 8%) whereas the lowest value was in female of *P. semisulcatus* (11.01%) (Fig.2). The present data are higher than that of *P. semisulcatus* studied in the Mediterranean Sea by [14] and the jinga shrimp *Metapenaeus affinis* [23]. These fluctuations in results are due to periodic changes in temperature and other environmental factors [24]. Our results recorded significant differences between the two sexes of *M. monoceros* while no significant differences between males and females of *M. japonicus* and those of *P. semisulcatus* at $P > 0.05$ (Table1).

Generally, significant differences were recorded only in the crude protein content between the different shrimp species; *M. japonicus, M. monoceros* and *P. semisulcatus* at ($P > 0.05$) whereas, no significant differences in carbohydrate and lipid contents percentage at ($P > 0.05$).

3.1.1 Analysis of essential amino acids and non-essential amino acids:

Amino acids are the structure units of proteins and serve as body builders. They form various cells and support the body with energy [4]. Twelve amino acids have been resulted in muscles of studied prawn species (*M. japonicus, M. monoceros* and *P. semisulcatus*). Nine EAAs (arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine and valine) were recorded in the muscles of the studied shrimps which are (Table 2). The results showed that their concentrations varied among different species as well as among sexes of each species. It was noticed that arginine was the main essential amino acid in all shrimps reaching the highest concentration in female *M. japonicus* (5.87 mg/ 100g). On the other hand, methionine attained the minimum values in the males and females of *M. japonicus* (0.86, 1.01 mg/100g, respectively) (Table 2). The arrangement of essential amino acids (EAAs) in combined sexes of the studied shrimps was illustrated in Fig. (3). In comparison with the other studies, in the shrimp *Macrobrachium rosenbergii* nineteen amino acids were recorded (eleven are EAAs and eight are NAAs [4]. On the other hand, [25] detected 9 essential and 9 non-essential amino acids in edible muscles of *Procambarus clarkii* and *E. massavensis.* The variation in essential and non-essential amino acids content in different crustaceans may be attributed to geographical factors, species, sex, age [26] and molting stage [13]. Arginine is the most important amino acid in the crustacean muscles for the regulation of osmotic pressure [25]. This result is similar to that recorded by [14] and [1]. Statistical analysis showed significant differences between sexes of the same species in all EAAs, with some few exceptions like histidine and isoleucine in *P. semisulcatus* also, the amino acid leucine in both sexes of *M. japonicus* and *P. semisulcatus* (Table 2).

Three non-essential amino acids, aspartic acid, glutamic acid and glycine are present of which glutamic acid recorded the highest concentration. Males of the three shrimps showed higher concentrations of glutamic and aspartic acids than those of females whereas glycine acid concentration was higher in the edible muscles of females than those of males (Fig.4). Significant differences were recorded in NEAA contents between males and females of the same species at $P > 0.05$ (Table 3). This result is similar to the result of [1]. Glutamic acid and glycine are the main components of glutathione that is an important natural antioxidant agent [27]. Therefore, these shrimps can be used as antioxidant agents that have a critical role in body protection.

3. 2 Vitamin B analysis:

Information about shrimp's vitamin content is rare. [28] revealed that crustaceans had higher number of total vitamins than that presented in fishes and shell fishes. Vitamins B1 (thiamin) and B2 (riboflavin) were analyzed in the studied species. It was noticed that content of B2 was greater than B1. Females *M. japonicus* had the highest concentrations of B1 and B2 (0.416 and 0.554 mg/ 100g, respectively) while the lowest were attained in males of *P. semisulcatus* (0.282 and 0.351 mg/ 100g, respectively) (Fig.5). Comparing between sexes, results show that vitamins B1 and B2 in females were higher than in males. Also, it was recorded that the concentrations of vitamin B2 was higher than that of B1 in both sexes of the three species. Obvious significant differences were attained between males and females of each species at $P > 0.05$. (Table 4). The variations in vitamin contents among males and females could be attributed to sex changes [28]. Similar results were attained in the muscle of *Penaeus indicus* from the Mediterranean [1]. The high level of vitamins B1 and B2 demonstrated the high nutritive value of the shrimps. ANOVA test revealed significant differences between the studied species in vitamin B2 content while no significant difference was recorded in vitamin B1 (Table 4).

3.3 Mineral analysis:

Calcium, iodine, magnesium, phosphorus and potassium are very essential minerals for human health and they are the main component of hormones, enzymes and enzyme activators [29]. Calcium is necessary for human because it does not only build bones and teeth but also it enables blood clotting, muscles contraction and heart beating [30, 31]. Edible parts of crustacean are main source of several minerals such as calcium, potassium, phosphorus, zinc and iron [32, 33]. Body surfaces and gills of shell fishes and fishes absorb minerals directly from the marine environment [34].

Four minerals; phosphorus, calcium, sodium and potassium are recorded in the examined shrimps of which phosphorus and calcium recorded the highest concentration while potassium and sodium were found in minimum concentrations irrespective to sex (Fig.6). The descending arrangement was as follow: P > Ca > Na > K. [35] found similar results, where calcium and phosphorus were the main minerals in fish skeleton. These results are comparable with studies of [36], where phosphorus and calcium in the present study are higher than those recorded in *P. semisulcatus* from the Mediterranean Sea (Port Said) and lower than those collected from the Red Sea. On the other hand, sodium had approximately the same concentration in that of Mediterranean but higher than that of the Red Sea. And by comparing the mineral concentrations of *M. monoceros* resulted in this study to that collected from the Arabian gulf [36] it could be noticed that the four investigated minerals had nearly the same values. Males displayed the maximum contents for P, K and Ca in all species in comparison with females. On the other hand, females' muscles of *M. japonicus*, *M. monoceros* and *P. semisulcatus* have exceeded that of males in Na contents (361, 311 and 362 mg/ 100 g, respectively), Significant differences were recorded in the four minerals contents between sexes of the same species at $P > 0.05$ (Table 5). Seasonal changes, different environmental conditions, biological differences, feeding habit and diet composition are factors affecting the mineral composition of edible sea food [37]. In general, the recorded data declared that the muscles of the three studied shrimps are rich in P and Ca compared with K and Na, so it is recommended to be consumed by human to get necessary mineral. The values of minerals achieved from the examined shrimp species show a significant difference at $P > 0.05$. Samples studied in this study had considerable concentrations of P, Ca, Na and K, recommending that these shrimp species are a good source of nutrient minerals.

4. CONCLUSION

The shrimps species (*Penaeus semisulcatus, Marsupenaeus japonicus* and *Metapenaeus monoceros*) examined in this study are good sources of proteins, vitamin B and mineral supply. Protein, vitamin B2 and mineral levels especially the phosphorus content in *Marsupenaeus japonicus* recorded the highest values among the studied shrimps. In conclusion, the shrimp *M. japonicus* has the best nutritive value where the nutritional analysis of edible muscles of the other two studied shrimps species (*M. monoceros* and *P. semisulcatus)* indicate the presence of high amount of proteins, enough content of lipids, low level of carbohydrates. Females had higher vitamins B1 and B2 contents than males and vitamin B2 was higher than vitamin B1. Both sexes of different species are rich in phosphorus and calcium.

Table 1. Percentages of total moisture, protein, carbohydrates and lipids in muscle of males and females shrimp's species in the western Mediterranean Sea.

	M. japonicus		***M. monocerous***		***P. semisulcatus***	
	Males	**Females**	**Males**	**Females**	**Males**	**Females**
Moisture (%)	71.23± 0.4 a	72.56 ± 1.2b	72.1±0.3a	71.22±0.1a	75.1±0.4a	75.43±0.2b
Protein (%)	50.12 ± 1.02a	51.37 ± 1.22b	42.39±0.36b	41.98±1.15a	38.45±0.89a	39.19±1.15b
Carbohydrates (%)	2.09 ± 0.03a	1.65 ± 0.02a	1.44±0.01a	1.35±0.02a	3.1±0.06a	1.79±0.04a
Lipids (%)	12. 8 ± 0.01a	13.01 ± 0.21b	12.02±0.08a	12.51±0.06a	11.07±0.11a	11.01±0.28b

Values are expressed as means ± S.D. of five samples; values of each parameter marked with different symbol letter are not significant difference (P>0.05), when comparing males and females of the same species.

Table 2. Essential amino acids (EAAs) analysis of muscle of males and females of the three shrimps in the study area.

EAAs mg/ 100 g	***M. japonicus***		***M. monocerous***		***P. semisulcatus***	
	Males	Females	Males	Females	Males	Females
Arginine	5.23 ± 0.02a	5.87±0.02a	4.5±0.01a	4.97±0.01a	3.58±0.07a	3.77±0.06a
Histidine	1.97±0.02a	2.03±0.01a	1.10±0.01a	1.05±0.03a	1.33±0.08a	1.28±0.06b
Isoleucine	2.40±0.03a	2.34±0.01a	1.24±0.01a	1.41±0.03a	1.19±0.08a	1.03±0.07b
Leucine	2.99±0.02a	2.98±0.02b	2.92±0.01a	2.03±0.01a	2.62±0.06a	2.64±0.06b
Lysine	2.06±0.02a	2.55±0.02a	0.97±0.01a	1.01±0.02a	1.50±0.08a	1.24±0.07a
Methionine	0.86±0.03a	1.01±0.01a	1.03±0.01a	0.99±0.01a	1.26±0.07a	1.36±0.06a
Phenylalanine	2.58±0.02a	2.48±0.01a	2.45±0.01a	2.06±0.01a	2.04±0.08a	2.26±0.08a
Threonine	2.30±0.02a	2.0±0.01a	2.64±0.01a	2.11±0.03a	1.57±0.08a	1.23±0.06a
Valine	2.17±0.02a	2.37±0.01a	2.18±0.01a	2.98±0.03a	1.92±0.07a	1.37±0.08a

Values are expressed as means ± S.D. of five samples; values of each parameter marked with different symbol letter are not significantly different (P>0.05), when comparing males and females of the same species.

Table 3. Non-essential aminoacids (NEAAs) analysis of muscle of males and females of the three shrimps in the study area.

NEAAS mg/ 100 g	*M. japonicus*		*M. monocerous*		*P. semisulcatus*	
	Males	Females	Males	Females	Males	Females
Aspartic acid	2.42 ± 0.05a	2.31 ± 0.05a	3.74 ± 0.02a	3.13 ± 0.01a	4.62 ± 0.05a	4.13 ± 0.04a
Glutamic acid	4.14 ± 0.02a	3.90 ± 0.05a	4.82 ± 0.06a	4.02 ± 0.07a	4.81 ± 0.06a	4.01 ± 0.06a
Glycine	2.19 ± 0.01a	2.22 ± 0.01a	2.24 ± 0.01a	2.28 ± 0.02a	2.49 ± 0.01a	2.69 ± 0.01a

Values are expressed as means ± S.D. of five samples; values of each parameter marked with different symbol letter are not significantly different (P>0.05), when comparing males and females of the same species.

Table 4. Vitamins B1 and B2 content (mg/ 100 g) in muscle of males and females of the three shrimps in the study area.

Vitamins	*M. japonicus*		*M. monocerous*		*P. semisulcatus*	
	Males	Females	Males	Females	Males	Females
B1	0.389 ± 0.01a	0.416 ± 0.01a	0.358 ± 0.02a	0.401 ± 0.01a	0.282 ± 0.02a	0.356 ± 0.01a
B2	0.502 ± 0.01a	0.554 ± 0.00a	0.498 ± 0.01a	0.521 ± 0.01a	0.351 ± 0.01a	0.387 ± 0.00a

Values are expressed as means ± S.D. of five samples; values of each parameter marked with different symbol letter are not significantly different (P>0.05), when comparing males and females of the same species.

Table 5. Mineral analysis (mg/ 100 g) in muscle of males and females of the three shrimps in the study area.

Minerals (mg/100g)	*M. japonicus*		*M. monocerous*		*P. semisulcatus*	
	Males	Females	Males	Females	Males	Females
Ca	408 ± 0.88a	400 ± 1.36a	449 ± 1.09a	415 ± 1.85a	485 ± 0.65a	405 ± 0.19a
K	265 ± 1.09a	211 ± 0.98a	294 ± 0.36a	273 ± 0.20a	209 ± 0.30a	205 ± 0.12a
Na	326 ± 0.61a	361 ± 0.87a	301 ± 0.61a	311 ± 0.81a	350 ± 1.03a	362 ± 1.01a
P	837 ± 1.15a	787 ± 1.63a	702 ± 0.9a	690 ± 1.4a	638 ± 1.44a	532 ± 0.80a

Values are expressed as means ± S.D. of five samples; values of each parameter marked with different symbol letter are not significantly different (P>0.05), when comparing males and females of the same species.

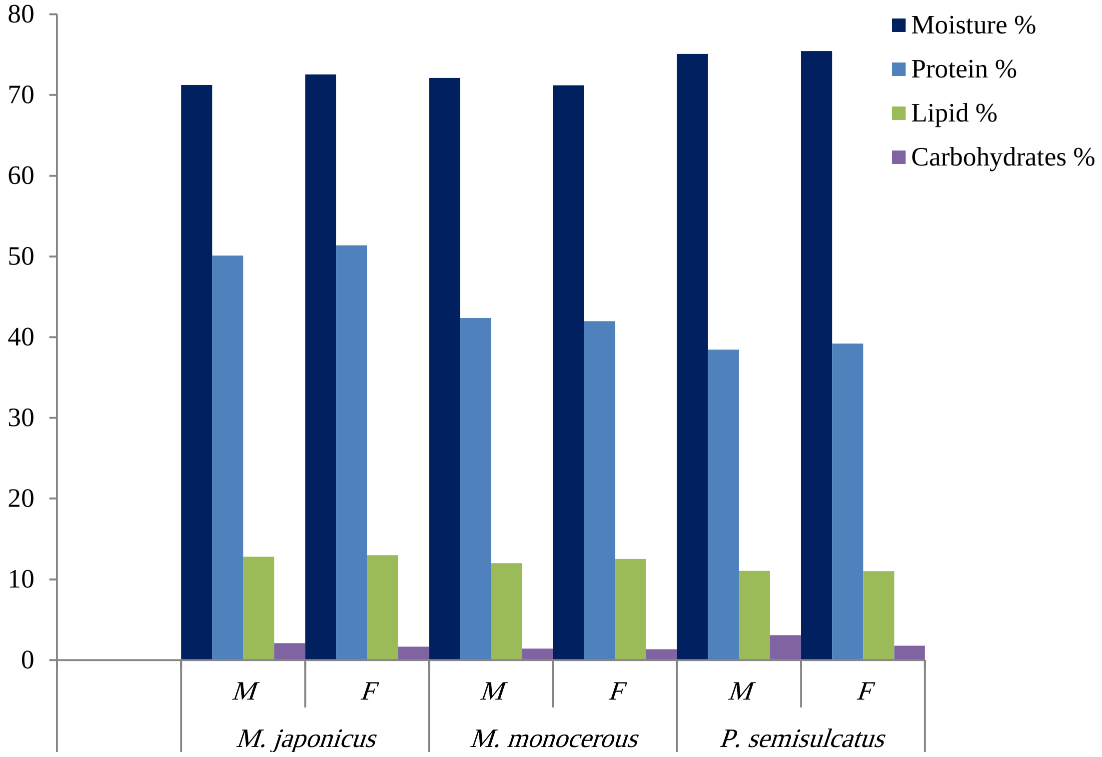

Fig.(2): Total percentage % of biochemical constituents in muscles of the studied shrimps

M= Males, F = Females

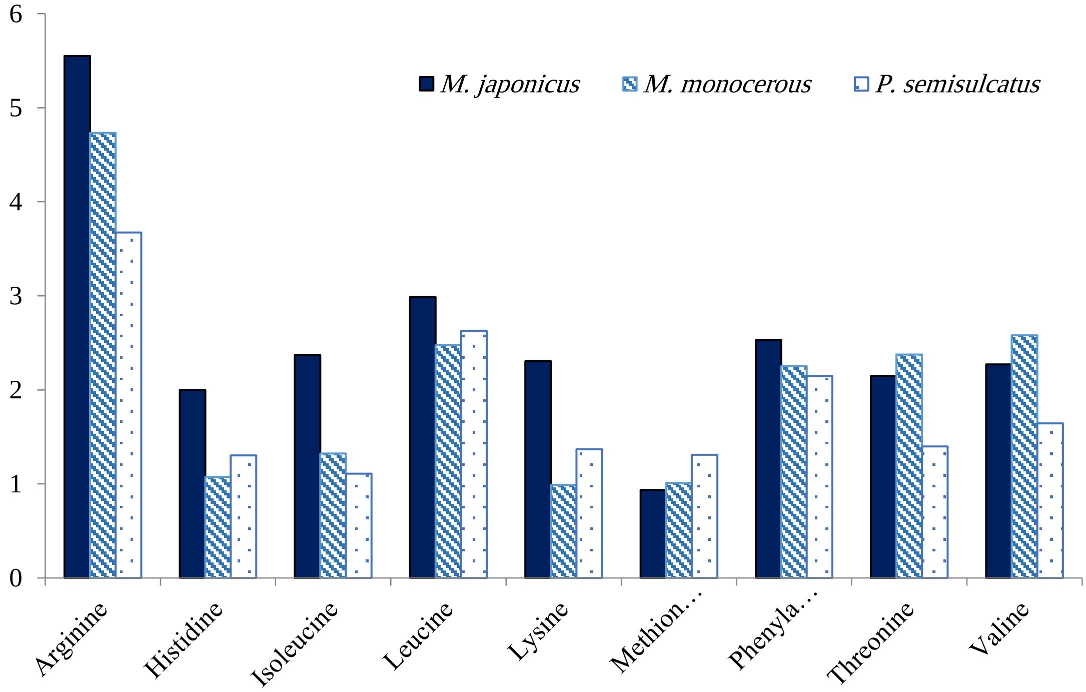

Fig. (3): Essential amino acids contents (mg/100g) in muscles of combined sexes of the studied shrimps

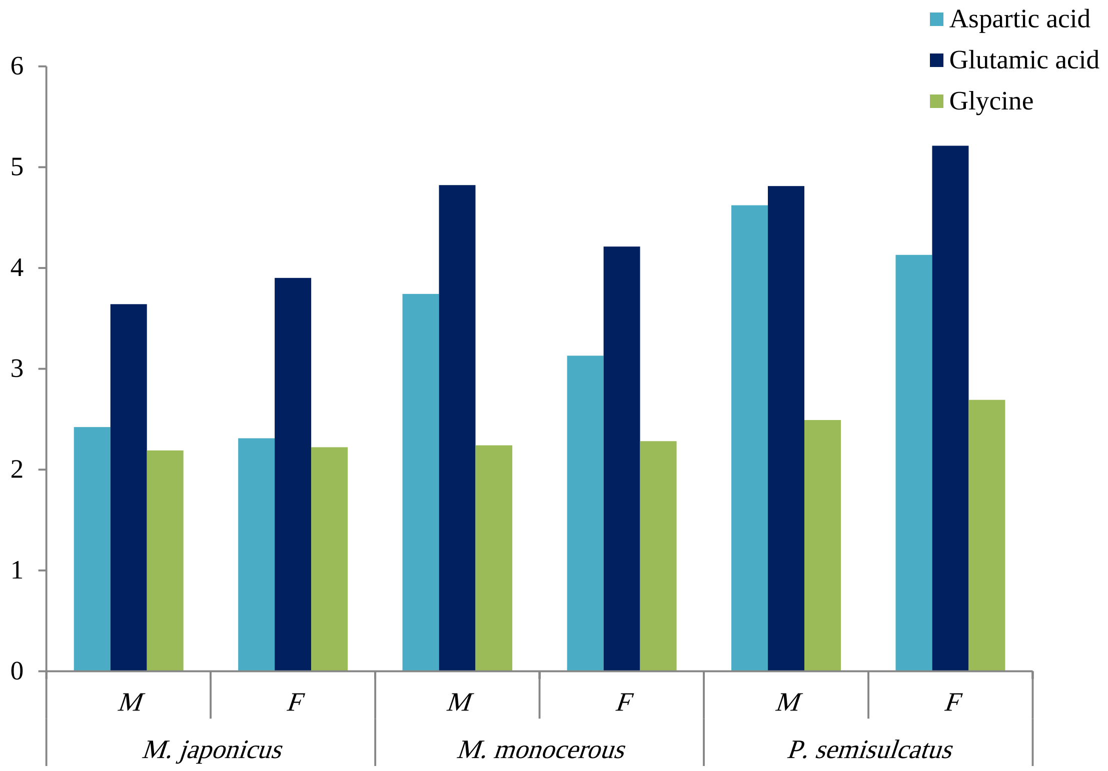

Fig.(4): Non-essential amino acids analysis in muscles of the studied shrimps

M= Males, F = Females

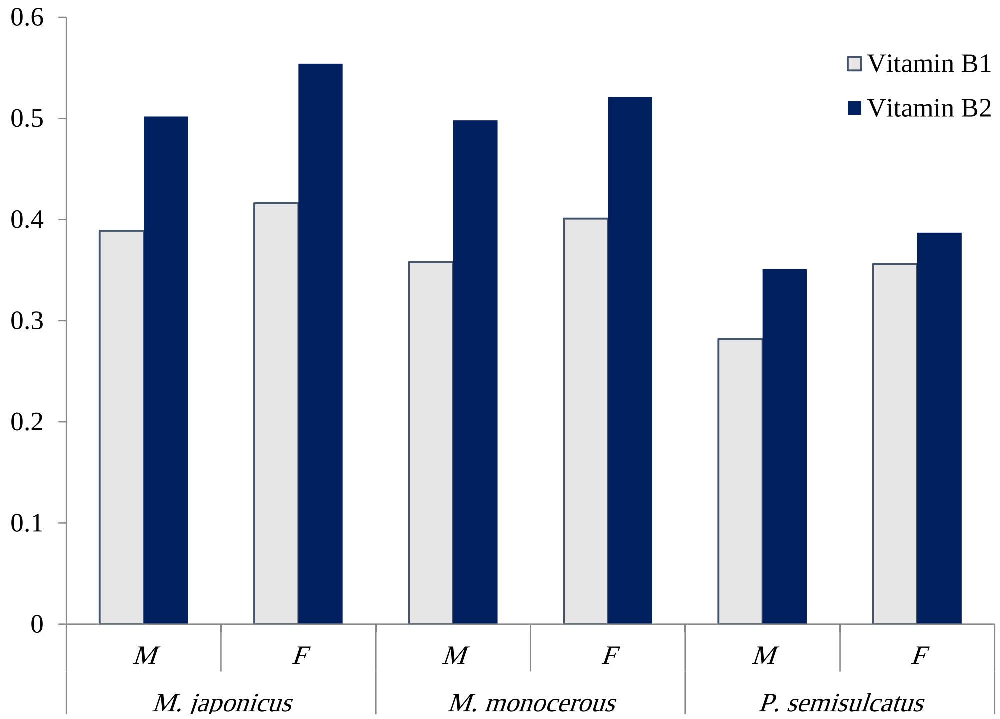

Fig. (5): Vitamins B1 and B2 content (mg/ 100 g) in muscles of the studied shrimps

M= Males, F = Females

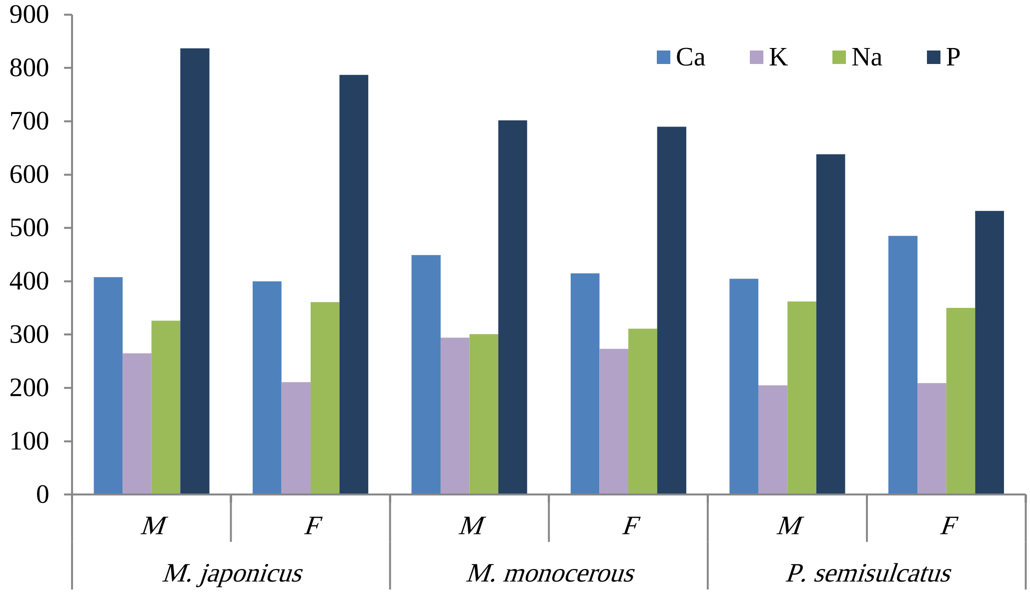

Fig. (6): Minerals content (mg/ 100 g) in muscles of the studied shrimps.

M= Males, F = Females

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