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COMPOSITIONAL ENERGY VALUES, MACRO AND TRACE ELEMENTS IN THE CARIDEAN SPECIES, *Macrobrachium macrobrachion* (HERKLOTS, 1851)

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Abstract: *Edible crustaceans, such as prawns, are one of the most nutritious shellfish available to humans. Meanwhile, the macro-micro nutrient content of seafood determines their nutritional value. The study assessed the energy values, macro and trace elemental residues in the caridean species, Macrobrachium macrobrachion from the Lagos Lagoon in Nigeria. The protein contents obtained from M. macrobrachion were 50.16±0.00 % and 56.20±0.01 % for exoskeleton and flesh samples respectively. Crude fiber and total ash contents were significantly (P < 0.05) higher in exoskeleton compared to the flesh part. Flesh sample had the highest proportion of energy contribution, which was from protein (PEP = 63.8 %) while the least energy contribution was from fat (PEF = 17.0 %) in exoskeleton sample. The value of total macro element was higher in exoskeleton sample (626.23 mg 100g^{-1}) than in flesh sample (402.28 mg 100g^{-1}). The highest percentage difference (% D) in mineral content between exoskeleton and flesh samples of M. macrobrachion was recorded in phosphorus with the value of 46.93 %. All the computed mineral ratios were comparably lower than the reference values. Furthermore, all the minerals had calculated Mineral Safety Index lower than the tabulated, showing positive percentage differences ranging from 74.67 to 90.61 % and 85.07 to 93.65 % for exoskeleton and flesh samples respectively. The trace metal result showed that iron, zinc and copper were the most abundant elements in exoskeleton and flesh of M. macrobrachion whereas chromium, lead and cadmium were the least abundant trace element detected. Furthermore, most of the trace metal levels recorded in this study were below the maximum permitted concentrations. The nutrient composition recorded for M. macrobrachion implies that it could be a healthy diet option for health-conscious consumers.*

Keywords: *Biochemical profile, trace metal, prawn, shellfish, Nigeria*

1. Introduction

Prawns and shrimps are morphologically identical and closely related, belonging to the same order Decapoda of the Crustacea class and only differing in their gill structure [1], yet they are often used interchangeably. Prawns are physically identical and closely related to shrimps, belonging to the same order Decapoda of the class Crustacea and only differing in their gill structure [1], though they are mostly used interchangeably. Traditionally, shrimps/prawns have become one of the most highly traded seafood resources. They are recognized as an important commodity in the international fishery trade and there is evidence of a rise in the consumption of crustaceans worldwide [2-3]. Marine shrimps dominate the production of typically farmed crustaceans in coastal aquaculture and are an important source of foreign exchange earnings for a number of developing countries, with catches reaching new peaks of over 336,000 tons in 2018 [4]. Among caridean species, *Macrobrachium macrobrachion* (Brackish water prawn) has been identified as one of the most important economic resources in the world crustacean fishery and aquaculture farming industry.

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The prawn has an extensive distribution across the Southern region of Nigeria and has being described as one of the largest species in the genus *Macrobrachium* [5]. According to Akinwunmi and Moruf [6], *M. macrobrachion* is commercially important and sustain viable artisanal fisheries in some water bodies within the region while providing direct and indirect employment.

Edible crustaceans such as prawn, crayfish, lobster and crab constitute one of the major sources of nutritious food for human nutrition, providing an important amount of dietary protein and lipid diet in many countries. They also contain several dietary minerals, which are essential, beneficial and play an important role in maintenance of physiological and biochemical activities in human beings [7-8]. These nutritive values of crustaceans depend upon their macro-micro nutrient composition, such as carbohydrates, protein, amino acids, lipids, fatty acids, minerals and vitamins. This body composition is a good indicator of physiological condition of an organism [9]. The current wave of scientific literature which links diet with the incidence of certain diseases has brought seafood to the attention of the health-conscious public. Crustaceans are known to dwell on sediment which is a sink for trace metals in aquatic ecosystems. Meanwhile, crustaceans accumulate trace elements in their tissues whether or not these elements are essential to their metabolism [10-11]. Hence, the need to assess the nutritive quality of prawn and associated species from the Lagos Lagoon in terms of its proximate composition and trace metals since these crustaceans are a major source of food and economically important to the coastal community. This study aimed to investigate the nutrient quality and energy values contributed by the nutrients in *M. macrobrachion* from the Lagos Lagoon as well as examine the presence of trace metals in the tissues of the species. This will serve to validate the current nutritional studies of West Africa *Macrobrachium spp.* in Nigeria.

2. Materials and methods

2.1 Collection and Preparation of Specimens

Samples of *M. macrobrachion* were collected from fisher–folks who employed fish cages and woven cylindrical non-return valve traps for prawn capture, along Makoko Jetty of the Lagos Lagoon. The lagoon lies between Latitudes 6º 26′ and 6º 39′N and Longitudes 3º 29′ and 3º 50′E. Lagos Lagoon is a part of a continuous system of lagoons and creeks’ lying along the coast of Nigeria and it is an open tidal estuary situated within the low-lying coastal zone of Nigeria [12].

One hundred and sixty (160) fresh samples were collected over four months (March – June 2021). The samples were rinsed with ultrapure water to remove foreign particles and patted dry with paper towels. The samples were transported in a 10 L bucket to the laboratory and processed within 4 hours of the collection. The fresh samples were identified using Identification Guides [13]. Routine body measurement (total prawn length) was determined using a 30 cm plastic ruler. The average length of the samples was 8.6 cm. Each shrimp was separated into exoskeleton and flesh, dried under 60ºC, grounded into powder and homogenized.

2.2 Laboratory Analysis

Methods of the Association of Official Analytical Chemists [14] were adopted for moisture, crude fibre, protein, fat, ash and carbohydrate analyses. By means of the already confirmed amount of proteins and fat, the energy content of the edible part of the organism was calculated. The energy values (KJ 100g^{-1}) of the specimen were estimated, multiplying the amount of proteins (%) by factor 17.16 and multiplying the amount of fat (%) by factor 38.96 and then calculating the number of the two already determined values [15].

Using a flame photometer (model 405, corning, U.K), the macro minerals (sodium and potassium) were determined while the trace metals were determined using an Atomic Absorption Spectrophotometer (Perkin & Elmer model 403, USA) [16]. Mineral Ratio and Mineral Safety Index were calculated according to formulae described by Santoso [17] and Hatcock [18] respectively.

2.3 Statistical Analysis

Data were analyzed using the descriptive statistic SPSS (version 20). Each value was a mean of six (6) replications. Differences in means were tested using t-test with the significance level set at P<0.05. Results were expressed as means, standard deviations (SD) and Coefficient of variation per cent (CV %).

3. Results

3.1 Energy Value Contributed by Nutrients in Caridean Species

The proximate composition of exoskeleton and flesh of *M. macrobrachion* is shown in Table 1. Higher level of moisture content was noticed in the flesh than that of exoskeleton sample. The protein contents obtained from *M. macrobrahion* were 50.16±0.00 % and 56.20±0.01 % for exoskeleton and flesh samples respectively. Fat content was higher in the flesh (9.04±0.00 %) than what was obtained in the exoskeleton (7.00±0.06 %). However, the contents of crude fiber, total ash and carbohydrate were higher in the exoskeleton sample with respective values of 2.02±0.12 %, 16.30±0.11 % and 6.37±0.05 %. Significant (P < 0.05) differences were observed in crude fiber and total ash contents of exoskeleton and flesh of *M. macrobrachion.* The highest percentage proximate difference (%D) between exoskeleton and flesh samples of *M. macrobrachion* was recorded in crude fibre content with the value of 57.43 %.

Table 2 shows the result of the percentage energy contribution by nutrients. Total metabolisable energy ranged between 1220.0 and 1381.0 kJ100g^{-1} (289.0 – 328.0 kcal 100g^{-1}). The highest proportion of energy contrition was from protein (PEP = 63.8 %) in flesh sample, while the least energy contribution was from fat (PEF = 17.0 %) in exoskeleton samples. Similarly, the utilizable energy due to protein (UEDP %: assuming 60% of protein energy utilization) was higher in flesh (38.3 kJ/38.0 kcal) than in exoskeleton samples (33.6 kJ/33.3 kcal) of *M. macrobrachion*.

Table 1

Proximate composition of the caridean species, *Macrobrachium macrobrachion*

Proximate (%)	Exoskeleton	Flesh	*P*-value	CV%	D	% D
Moisture	18.15±0.01	19.2±0.05	0.12	3.98	-1.05	-5.79
Protein	50.16±0.00	56.2±0.01	0.15	8.03	-6.04	-12.04
Crude Fat	7.00±0.06	9.04±0.00	0.07	17.99	-2.04	-29.14
Crude Fiber	2.02±0.12	0.86±0.05	0.04*	56.96	1.16	57.43
Total Ash	16.30±0.11	9.34±0.12	0.03*	38.39	6.96	42.70
Carbohydrate	6.37±0.05	5.36±0.01	0.09	12.18	1.01	15.86

***Keys**: Coefficient of variation per cent (CV %), Difference between exoskeleton and flesh (D), Percentage difference (% D). p < 0.05 with * indicate significant difference*

Table 2

Compositional energy values in *Macrobrachium macrobrachion*

Parameter	Unit	Exoskeleton	Flesh	Mean	SD	CV%
Total energy	kJ $100g^{-1}$	1220.0	1381.0	1300.5	113.8	8.8
	kcal $100g^{-1}$	289.0	328.0	308.4	27.2	8.8
PEF	% (kJ 100g-1)	17.0 (259)	22.3 (334)	19.7	3.8	19.2
	% kcal $100g^{-1}$	17.4 (63)	22.9(81)	20.2	3.9	19.3
PEC	% (kJ $100g^{-1}$)	7.1 (108)	6.1(91)	6.6	0.7	10.9
	% kcal $100g^{-1}$	7.0 (25)	6.0(21)	6.5	0.7	10.8
PEP	% (kJ $100g^{-1}$)	56.0 (853)	63.8 (955)	59.9	5.6	9.3
	% kcal $100g^{-1}$	55.4 (201)	63.3 (225)	59.4	5.6	9.4
UEDP%	kJ	33.6	38.3	35.9	3.3	9.3
	kcal	33.3	38.0	35.6	3.4	9.4

***Keys**: Proportion of total energy due to fat (PEF), Proportion of total energy due to carbohydrate (PEC), Proportion of total energy due to protein(PEP), utilization of energy value due to protein (UEDP%), Standard deviation (SD), Coefficient of variation per cent (CV%).*

3.2 Macro Elements in Caridean Species

The result of the mineral content is contained in Table 3. The total macro element was higher in exoskeleton sample (626.23 mg $100g^{-1}$) than in flesh sample (402.28 mg $100g^{-1}$). The highest percentage difference in mineral content between exoskeleton and flesh samples of *M. macrobrachion* was recorded in phosphorus with the value of 46.93 %. In exoskeleton samples, calcium (112.63±0.02 mg $100g^{-1}$) and phosphorus (303.91±0.05 mg $100g^{-1}$) were significantly higher ($p<0.05$) compared to that in flesh sample.

Table 3

Macro elements in the Caridean species, *Macrobrachium macrobrachion*

mg $100g^{-1}$	Exoskeleton	Flesh	*P*-value	SD	CV%	% D
Calcium	112.63±0.02	76.18±0.05	0.03*	25.77	27.30	32.36
Phosphorus	303.91±0.05	161.29±0.16	0.01*	100.85	43.36	46.93
Magnesium	52.3±0.07	32.44±0.03	0.09	14.04	33.14	37.97
Sodium	88.94±0.11	74.64±0.61	0.11	10.11	12.36	16.08
Potassium	68.45±0.23	57.73±0.04	0.16	7.58	12.01	15.66
Total	626.23	402.28				

***Keys**: Standard deviation (SD), Coefficient of variation per cent (CV %), Percentage difference (D). p < 0.05 with * indicate significant difference*

All the computed mineral ratios as contained in Table 4 were comparably lower than the reference values. Ideally, Ca/Mg should be a 7.0:1 ratio of calcium relative to magnesium with a range of 3.0 to 11.0 being acceptable. The result of the study gave a ratio of 2.15:1 and 2.35:1. The milliequivalent ratio, [K/(Ca+Mg)] with the values of 0.68 and 0.80 for exoskeleton and flesh samples respectively, were also lower than the reference balance of 2.2.

The values of the mineral safety index (MSI) in the caridean species, *M. macrobrachion* are shown in Table 5. The standard MSI tabulated for the investigated minerals are Ca (10), Mg (15), P (10) and Na (4.8). In this study, all the minerals had MSI calculated values lower than the MSI tabulated, thereby showing positive percentage differences, ranging from 74.67-90.61 and 85.07-93.65 for exoskeleton and flesh samples respectively.

Table 4

Elemental ratio in the Caridean species, *Macrobrachium macrobrachion*

Parameter	Reference	Ref. range	Exoskeleton	Flesh	SD	CV%
Ca/Mg	7	3 to 11	2.15	2.35	0.14	6.12
Ca/K	4.2	2.2 to 6.2	1.65	1.32	0.23	15.54
Ca/P	2.6	1.5 to 3.6	0.37	0.47	0.07	17.07
Na/K	2.4	1.4 to 3.4	1.3	1.29	0	0.35
Na/Mg	4	2 to 6	1.7	2.3	0.42	21.22
[K/(Ca + Mg)]	2.2		0.68	0.80	0.08	11.47

***Keys**: Standard deviation (SD), Coefficient of variation per cent (CV %). Source for Reference value: Watt [24]*

Table 5

Mineral Safety Index (MSI) in the Caridean species, *Macrobrachium macrobrachion*

Mineral	MSItv	Exoskeleton			Flesh			Mean	SD	CV%
		MSIcv	D	%D	MSIcv	D	%D			
Ca	10	0.94	9.06	90.61	0.63	9.37	93.65	0.79	0.21	27.3
Mg	15	1.96	13.04	86.93	1.22	13.78	91.89	1.59	0.53	33.14
P	10	2.53	7.47	74.67	1.34	8.66	86.56	1.94	0.84	43.36
Na	4.8	0.85	3.95	82.21	0.72	4.08	85.07	0.79	0.1	12.36

***Keys**: MSI Table value (MSItv), MSI calculated value (MSIcv), Difference between MSItv and MSIcv (D), Percentage difference (% D), Standard deviation (SD), Coefficient of variation percent (CV%).*

3.3 Trace metal residues in Caridean species

The trace metal result showed that Fe, Zn and Cu are the most abundant elements in exoskeleton and flesh of *M. macrobrachion* whereas Cr, Pb and Cd are the least abundant trace elements detected (Fig. 1). The rank profile of the trace metal levels in the exoskeleton part followed the pattern Fe>Zn>Cu>Mn> Cr>Pb>Cd with respective mean concentration (mg $100g^{-1}$) of 11.95, 7.25, 5.58, 3.28, 1.10, 0.91 and 0.03. Also, the ranking profile of trace metal concentration in flesh was Fe>Zn>Cu>Mn> Pb> Cr>Cd with respective mean concentration (mg $100g^{-1}$) of 8.25, 6.11, 3.53, 1.53, 0.89, 0.85 and 0.02.

4. Discussion

The exoskeleton and flesh of *M. macrobrachion* had similar proximate compositions except for crude fiber and total ash, which were significantly higher in the exoskeleton. The higher carbohydrate content of exoskeleton indicates that it could be used to manage protein-energy malnutrition. A similar study on *M. vollenhovenii* body parts found that the exoskeleton had more crude fiber, ash, and carbohydrate content than the flesh [19]. The protein composition recorded in the present study was higher in value compared to that reported for *M. vollenhovenii*: 46.06 ± .38 % [20] and 41.94± 0.69 % [19], but comparable to that reported for *M. macrobrachion* (56.15 ± 3.82) from Ovia River in Edo State, Nigeria [21]. The high content of protein recorded in this study indicated that *M. macrobrachion* is a good source of amino acids. High protein content in this species can be attributed to its omnivorous feeding habit. The total energy value contributed by nutrients was higher in the flesh part compared to the exoskeleton part of *M. macrobrachion.* Furthermore, the highest proportion of energy contribution was from protein in flesh sample, while the least energy contribution was from fat in exoskeleton samples. The values of total metabolisable energy were higher than 457 kJ $100g^{-1}$ reported for *Cardisoma amartum* [22].

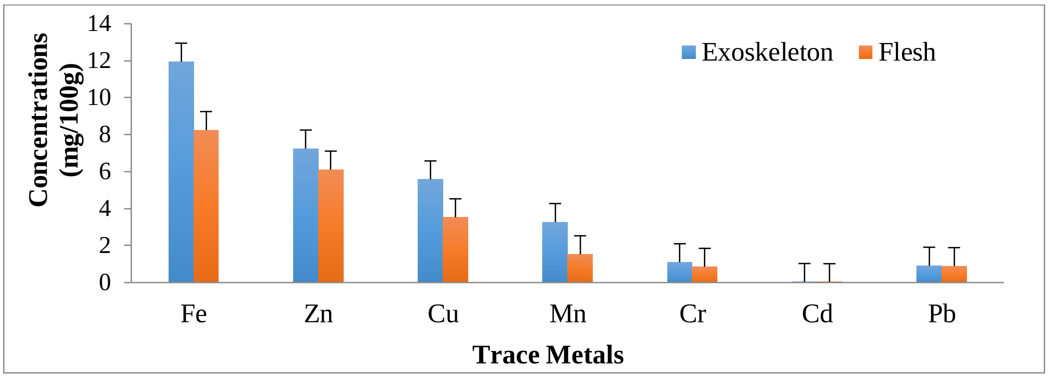

Fig. 1: Trace element in the caridean species, *Macrobrachium macrobrachion*

All the investigated macro elements (minerals) were higher in exoskeleton than in the flesh. The reason may be due to the fact that most of these minerals such as calcium/magnesium are used to build up the shells. All the mineral elements were more positive towards the exoskeleton sample. This preponderance shows the mineral abundance in the exoskeleton part of the crustacean, similar to the report of Moruf et al. [23] on the flesh and shell of *Callinectes amnicola* from the coastal waters of Lagos, Nigeria. Also in the present study, the result of macro elements concentration in both parts of *M. macrobrachion* indicates a decreasing order of calcium > magnesium > phosphorus > sodium > potassium. Lawal-Are et al. [8] have reported a similar decreasing order of mineral content for the whole and fillet of Guinean Mantis Shrimp, *Squilla aculeata calmani*.

Mineral ratios revealed the significant balance between elements and provide details on many factors that can be represented by a disruption of their relationships [24]. In the present study, all the computed mineral ratios were comparably lower than the reference values [24]. The milliequivalent ratios [K/(Ca+Mg)] were also lower than the reference balance, contrary to Adeyeye et al. [25], who reported a higher milliequivalent ratio of 12.8:1 to 14.7:1 on the furs of some selected domestic animals.

In the present study, all the minerals had calculated mineral safety index values lower than the tabulated, indicating that the consumption of *M. macrobrachion* will not cause mineral overload thus, avoiding the possibility of secondary hypertension [26-27]. This is in line with the report by Moruf et al. [28] that Ca, P and Na in the Royal Spiny Lobster (*Panulirus regius*) would not constitute mineral overload to consumers.

There are numerous factors affecting trace metal level in prawns such as parts of prawn, seasonal variation and sexes [29]. In this research, we focused on parts of prawn. The prawn exoskeleton contained the highest levels of trace metal residues is not surprising, as the exoskeleton at the head region contains hepatopancreas, an organ which is an essential metal storage site in decapod crustaceans [30]. According to Silva et al. [31], accumulated cadmium is primarily concentrated in the hepatopancreas. Thus, the exoskeleton of *M. macrobrachion* is a good indicator tissue for metal monitoring compared to the flesh part. This result compared well with those reported for decapod crustaceans from Southwest Nigeria [32-34]. Furthermore, most of the trace metal levels recorded in this study were below the maximum permitted concentrations (mg/kg) for Fe (425.5), Zn (99.4), Cu (73.3), Mn (0.5), Cr (5.0) Cd (0.2) and Pb (0.3) [35].

5. Conclusion

The study found that the concentrations of important nutrients in *M. macrobrachion* varied with respect to body parts. The exoskeleton had appreciable levels of macro minerals, whereas the flesh part had more compositional energy from nutrients. The presence of Cd, Cr, and Pb in prawn tissues, on the other hand, indicates that the release of all of these trace metals into the aquatic medium as a result of anthropogenic activities must be controlled.

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