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NUTRITIONAL DATA ON *NEMATOPALAEMON HASTATUS* IN OKORO RIVER ESTUARY, SOUTHEAST NIGERIA

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ABSTRACT: *This study investigated the variations in proximate compositions of the shell and flesh Nematopaemon hastatus shrimps (crayfish). The results showed that the protein, carbohydrate and moisture contents in the flesh (54.3%; 24.12%; 65.30%) were higher than those of the shell (42.17%; 22.10%; 64.88%), respectively. The highest amounts of lipid and ash were found in shell, being 5.6%; 26.4%, respectively compared to the flesh values (3.28%; 21.22%). The protein to moisture ratio (P/M) was higher (0.8) for flesh than for shell (0.6) indicating higher quality of the latter. Study further indicates that the shell is a good source of inorganic minerals while the flesh is rich in nutrients, protein and metabolizable energy. Strong relationships were recorded between protein and body size (R^2 = 0.421), crude fiber and body size (R^2 = 0.501) at $p< 0.05$. The nutritional data of N. hastatus shrimps indicates that with proper dietary planning mothers, children and the aged could take advantage of its rich protein, yet very low fat and calorie content as a healthy food, snacks or food ingredient as part of the main meal. Furthermore, its use feed formulation for children and animals are recommended.*

KEYWORDS: Binary Coefficient, Calories, Dietary Planning, Nutritional Values

INTRODUCTION

The nutrient composition of different parts of the shell and flesh of estuarine decapod crustaceans such as shrimps, lobster and crabs is very important to different users including food processor, nutritionists, cooks and the consumers because they are abundant and are vital sources of animal protein and constitute a regular ingredient in the food intake of Nigerians and coastal dwellers, in particular. Shrimps constitute an important fishery resource and are strongly exploited by local communities around the Niger Delta, Nigeria. Apart from the supply of good quality proteins and vitamins A and D, shrimps also supply several dietary minerals such as calcium (Ca), Iron (Fe), etc., which are beneficial to man and animals [1]. These crustaceans perform various functions in the human body [2-4].

Several authors have established that significant differences exist between the proximate composition of shell and flesh of shrimps [5]. Fish as well as crustaceans when fed intensively, accumulate high carbohydrate and fat contents in their muscles and body tissues [6]. Variation was also observed in proximate compositions of shell and flesh of the Indian white shrimp *Penaeus indicus* from Southeast coast of India [7]. Their results indicated flesh protein and carbohydrate values of *P. indicus* were higher (41.3% and 2.4%) than those of shell (32.5% and 1.5%), respectively. While in the reverse, higher ash content (26.6%) was also reported in the shell than in flesh (18.5%) of the studied *P. indicus*. The protein level of 57.32 to 61.44% was obtained for edible Palaemonid prawn, *Macrobrachium idella idella* [8].

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Crude fibre was not detected in the exoskeleton of *Macrobrachium macrobranchium* of Ovia River in Benin, Nigeria, compared to its edible portion [9]. [10] also obtained protein (67.68-69.71%), fat (6.87 – 7.68%), ash (10.16-10.55%), fibre (0.40 – 0.54%), moisture (10.25 – 10.71%), and carbohydrate (0.58 – 3.65%) from the Caridean prawn (*M. vollenhovenni*) in the same Ovia River in Benin, southcentral Nigeria. Both authors reported higher protein, fat and carbohydrate values in the flesh or edible portion than that of the shell. Similar result was obtained for *Palaemon* species in the Lagos Lagoon, Nigeria [11].

The record of nutritional status of shrimps from the Okoro River, Niger Delta is scare. Hence, this study reports on some biochemical aspects and nutritional value of *N. hastatus* shrimps (also known as crayfish) of this important fishery resource to fill the gap in knowledge and stimulate both economic and fisheries management activities for its twin exploitation vis-a-vis conservation. In particular, this study evaluates the nutritional value of different body parts (particularly the shell and flesh) in selection and utilization of a particular species for consumption from the viewpoint of nutrition.

MATERIALS AND METHODS

Collection and proximate analyses of samples

One hundred and twenty (n=120), *N. hastatus* shrimps of the Okoro River estuary, southeast Nigeria (latitude 4^o 33$^’$N and 4 ^{o} 55$^’$ N and longitude 7^{o}45$^’$E and 7^0 55$^’$E, Fig. 1) were randomly sampled from both the dry and wet seasons from fishermen employing traditional beam trawl nets (*Uduut*) and landed at Elekpon along the estuary. The specimens consisting were washed with distilled water to remove adhering debris, allowed to drain and embedded in ice chest and transported to the laboratory for analysis. The carapace lengths and weights of the shrimps were measured in the laboratory with vernier calipers and electronic weighing balance to the nearest 0.01cm and 0.01g, respectively. Thereafter, the exoskeletons (comprising head and the outer body shell, i.e. shell) were separated from the endoskeletons (comprising the flesh or edible part) forming two sets, each comprising 60 specimens, for proximate analysis.

The two body parts were separately oven dried at 75^{0}C for 72 hours to ensure complete dryness; ground to fine powder in an electric blender, packed in labeled polythene bags and stored at 4˚C in refrigerator till chemical analysis. All the parameters were determined in triplicate samples (n = 3) following the method of [12]. Moisture was determined by the loss in weight of sample after drying in oven for 103^{o}C for 4 hours to constant weight and calculated as % of moisture weight loss x100/original weight of the sample taken [12]. The percentage moisture content was subtracted from 100% to obtain % dry matter (DM = 100 - % Moisture). Nitrogen (N) for crude protein (CP) was determined by the micro-Kjeldahl method and converted to crude protein as %N x 6.25 [12]. Lipids (fat) content was determined with the Soxhlet procedure [13-14] with ether as solvent to obtain ether extract (EE) fraction. Crude fibre (CF) was determined using muffle furnace. The percentage ash content was measured with corning flame photometer (UK model 405) after charring at 400-600^{o}C for 4hours. Carbohydrate was determined as Nitrogen Free Extract (NFE) by subtracting the sum of percentages of all the nutrients already determined from 100 (NFE = 100 – (%moisture ±%CF±%CP±%EE±Ash) [12]. The metabolizable energy was estimated from as: Energy value (Cal./100g) = (4 x protein)+ (4x carbohydrate) + (9x fat) [15].

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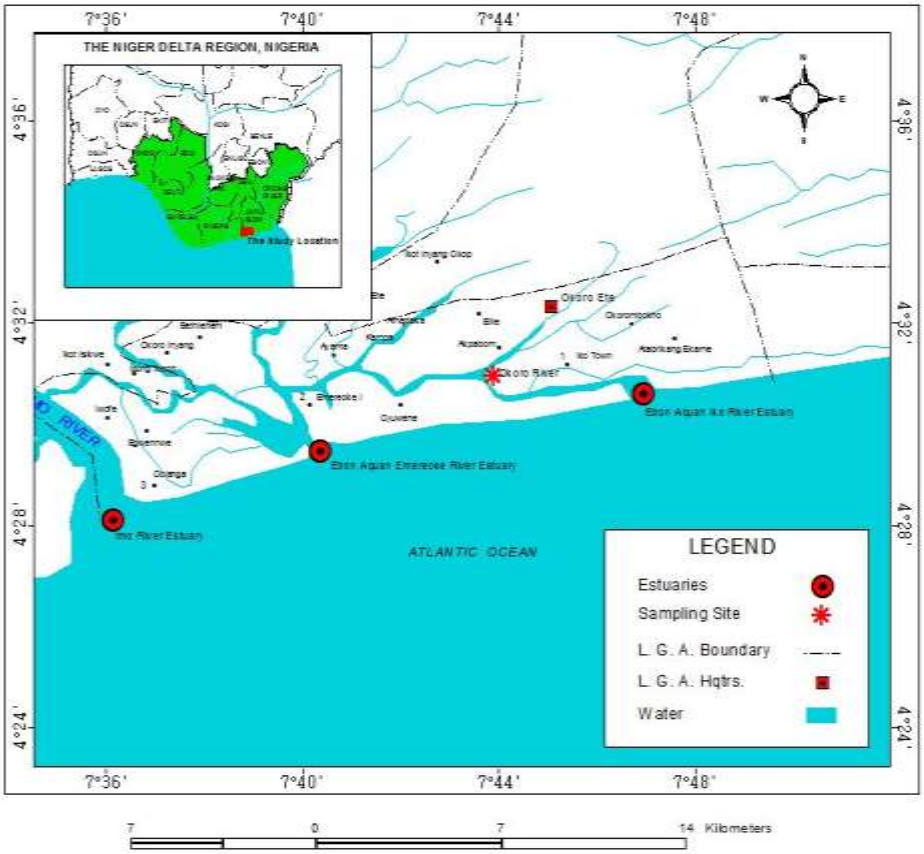

Fig 1. Location of sampling site on the map of Eastern Obolo in the Niger Delta, southeast Nigeria

Means ± standard deviation of proximate parameters based on body parts were calculated and subjected to one way analysis of variance, ANOVA [16-17] with statistical significance set at $p < 0.05$. In addition the coefficient of variation (CV), which is the standard deviation expressed as a percentage of the mean, was calculated.

Cluster analysis was used to discover the structure within the body of data to obtain an index of similarity or dissimilarity for each pair of parameter [17]. Multiple regression analysis was also performed to identify relationships between proximate components and shrimp body parts. All statistical analyses were performed using SPSS 19.0 and Microsoft Excel packages.

RESULTS

Results of proximate composition of shrimp body parts in Eastern Obolo estuary are summarized in Table 1. Shrimp flesh contain higher crude protein, carbohydrate and moisture (54.3 %CP, 24.12% CHO, and 65.30 % moisture, than their shell (42.17±0.56% CP, 22.1± 0.56% CHO and 64.88±0.057 % moisture), respectively. In the reverse, shrimp shells contained significantly ($p< 0.05$) higher amounts of lipid and ash content (5.64±0.01%, 3.28±0.011%, respectively) than in their flesh. Protein content of shrimp flesh was significantly ($p< 0.05$) higher than in their shells (Table 1). Results also indicate the shrimps are extremely a good source of protein, yet are very low in fat and calories, making them a

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healthy choice of food. The protein to moisture ratio (P/M) was higher (0.8) for flesh than for shell (0.6) indicating higher quality of the latter. Multiple regression analysis between proximate composition and body size (Carapace length, CL and body weight BW) are presented in Table 2. The results showed two (2) strong relationships at p< 0.05: protein x body size (R^2 = 0.421) and crude fiber x body size (R^2 = 0.501); and three (3) weak associations (Table 3): moisture, total ash and nitrogen free extract (R^2 = 0.2 - 0.3) while the least association was for lipid (R^2 = 0.18).

Table 1. Percentage mean values of proximate compositions for different shrimp parts of *N. hastatus* in Okoro River estuary, Southeast Nigeria (mean ± standard deviation of triplicate measurements)

Parameters	Endoskeleton	Exoskeleton	Pooled	CV	*P*
Moisture Content (%)	65.30± 0.100	64.88±0.057	65.09± 0.29	0.44	0.35
Dry Matter (%)	34.70± 0.57	34.85±0.010	34.77±0.10	0.28	0.25
Crude Protein (%)	54.31± 5.7	42.17±5.6	48.24±8.58	17.78	0.01*
Lipids (%)	3.28± 0.011	5.64±0.010	4.46±1.66	37.2	0.01*
Crude Fibre (%)	2.32± 0.010	3.69±0.012	3.00±0.96	32.0	0.68
Total Ash Content (%)	16.05±0.057	26.40± 0.052	21.22±0.11	0.51	0.002*
Nitrogen Free Extract (%)	24.12±0.635	22.10±0.56	23.11±1.42	6.14	0.10
Energy (Cal./ 100g)	343.24±2.3	307.84±2.8	325.54±18.87	5.80	0.64

* = significant (P<0.05) CV = coefficient of variation

Table 2. Multiple Regression Model between Proximate Composition and body size (Carapace Length and Fresh Body Weight) of *N. hastatus* in Okoro River estuary, Southeast Nigeria

Parameters	R	R^2	Adjusted R^2	Std	*P*	Regression Model: Y_0=a+ b_1Cl + b_2BW
Moisture	0.447	0.200^{w}	0.22	5.80	0.366	Y_0 = 62.475+0.786 CL-5.670 BW + e
Dry Matter	0.447	0.200^{w}	0.022	5.46	0.366	$\hat{Y}_0$ = 37.326- 0.745 CL+ 5.488 BW + e
Protein	0.649	0.421^{*s}	0.292	5.89	0.086	Y_0 = 49.134-0.768 CL+10.590 BW + e
Lipid	0.424	0.180^{vw}	-0.002	1.06	0.409	Y_0 = 3.171+0.114 CL-1.206 BW + e
Crude fibre	0.708	0.501^{*s}	0.390	0.47	0.044	$\hat{Y}_0$ = 2.359+0.085 CL-1.052 BW + e
Total Ash Content	0.507	0.257^{w}	0.091	3.87	0.263*	$\hat{Y}_0$ = 23.984+0.258 CL-268 BW + e
Nitrogen free Extract (CHO)	0.580	0.337^{w}	0.190	2.61	0.157*	Y_0 = 21.352+0.312 CL-4.064 BW + e

P = Probability Level *= significant (P<0.05) CL=Carapace Length, BW= Body Weight

Strength of association: w = Weak (R^2=0.1 -0.40), s = Strong (R^2=0.4-0.6), vw = Very weak (R^2=0.1 -0.20), CHO = carbohydrate

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The Cluster tree (or dendrogram, Fig. 2) presents euclidean distance of proximate compositions in dimensional space showing that the smaller the distance between cases, the greater the similarity. Values are shown as mean ± standard deviation of triplicate determinations of each parameter

DISCUSSION

The mean crude fibre content (3.00±0.96) observed in this study was quite low but higher in the exoskeleton (shell) than in the flesh of shrimps; contrary to reports of higher CF values in flesh (8.7%) than shell (8.2%) for *Penaeus indicus* [7] and zero crude fibre obtained in the exoskeleton of *M. macrobranchion* from Ovia River, Nigeria [9]. Similarly, mean carbohydrate contents in shrimp shell and flesh were also higher in *N. hastatus* (24.12% and 22.10%) in this study than

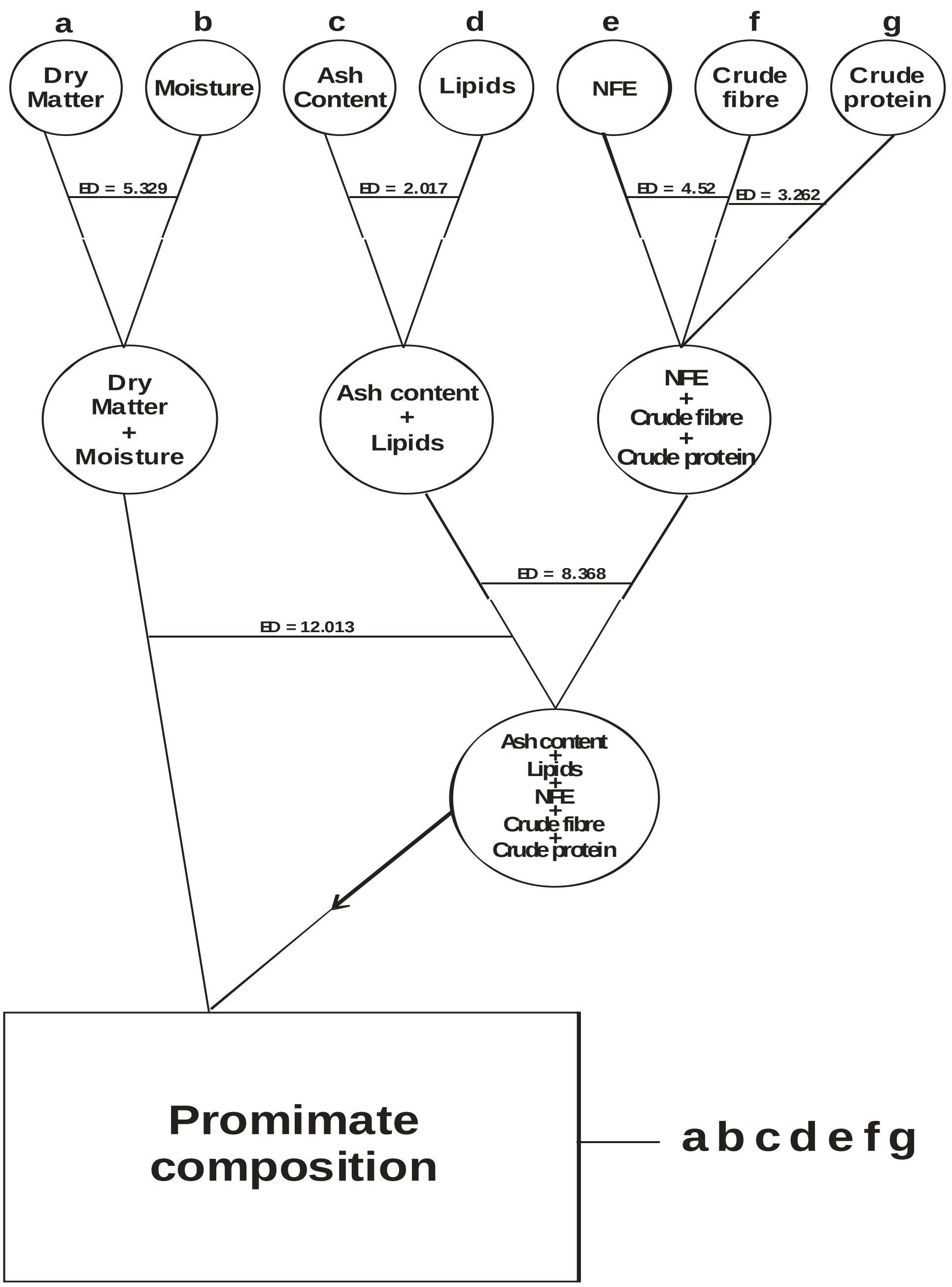

Fig. 2. Cluster tree (Dendrogram) of proximate composition in dimensional space. ED = Euclidean distance: the smaller the Euclidean distance, the closer the cluster group. The Euclidean distances between parameters are not equidistant.

in *M. vollenhovenii* (1.5% and 9.48%), respectively [7]. The moisture content of fresh shrimp in this study was similar to previous reports, 61% to 80% [18] indicating high water content in the shrimps studied. The crude protein levels for *N. hastatus* in this study (42.17 - 54.31%) falls within the average protein content for shrimps, 46.99±5.268 [19] and that reported for *P. indicus*, 41% (flesh) and 32.5% (shell) [7]. They were however, below those reported for edible Palaemonid prawn, *Macrobrachium idella idella*, 57.32 – 61.44% [8,20] and fresh water crabs [21] but higher than those obtained for *Caridina africana*, 18.98±0.002% [22]; and *M. vollenhovenii* - 16.99 ± 0.20, *M. macrobranchion* - 17.30 ± 0.30, *Penacus notialis* - 20.57 ± 0.05 and *Brachrus niger* - 18.52 ± 0.01 [23].

This study highlights the nutritional and economic values of *N. hastatus* shrimps from the Okoro estuary, Nigeria, indicating the flesh component are a richer source in protein (54.31± 0.3%) to consumers. The shells could also supply over 40% crude protein in fishmeal production and are a veritable source for replacement of other expensive protein sources in feed formulation for animals and children; and for human consumption.

The lipid values (Table 1) agree with those of *M. vollenhovenii* (5.62 ± 0.21%), *P. notialis* (3.90 ± 0.06%) and *C. africana* - 5.57 ± 2.05 [23, 24]. High levels of ash content (26.40%) were observed in shrimps of Okoro River estuary. This is similar to the report of 25.52% ash content in the shell portion and 16.76% for flesh (edible portion) of *Palaemon* species in the Lagos Lagoon, Nigeria [11]. The observations in dietary mineral suggest that the shrimp samples could provide a significant proportion of calcium, if consumed regularly. The higher ash compositions in the shell indicate higher mineral content in shell samples than flesh tissue. Comparison between the flesh and shell of shrimp shows that high level of protein, carbohydrate and moisture content was recorded in the flesh tissues, while higher level of lipid, fibre and ash content was noticed in the shell parts. The results indicate that the flesh of *N. hastatus* shrimps is a good source of nutrients, protein and metabolically energy while shell is a good source of essential mineral supply.

The minerals are involved in bone formation. They also play important role in blood clotting, muscle contraction and in certain enzymes activities during metabolic processes. Therefore the food ingredient is recommended for formulation of food for children and dietary requirement in formulating balanced feeds for other animals. Ash composition in *M. dobsoni* was 15.79% and 17.11% in Jawla prawn (*Acetes sp.*) [25]; lower than the values obtained in this study. The ash content (40.657%) for fresh water shrimps [9] is higher than 26.4% recorded in this study. High ash content in shrimps has been linked with high level of chitin strengthened by a high level of calcium metal in the exoskeleton. Similar observation was made of the exoskeleton of shrimps found in Lagos lagoon [1]. Chitin is a linear polymer of acetyl D-glucosamine that has properties similar to cellulose in many respects. It is involved in various physiological processes [1]. The structure of the glucosamine shows it must have contributed to both the carbohydrate and protein values.

The ash content or mineral levels in *N. hastatus* shrimps (also referred to as crayfish) in this study were lower than what was obtained in fresh water crabs [19] and land crab [26] but better than the mineral levels in the variegated grasshopper *Zonocerus variegates* [27]; close to the levels obtained for winged termites, *Macrotermes bellicosus* [28] but higher than the

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values obtained for termites, *Trinervitermes germinatus* ([29]. The average ash content 26.47 ± 0.18% for *N. hastatus* shrimps is higher than 18.3% ash in *Oreochromis niloticus* [31] but lower than 30.6% ash in *Clarias gariepinus* [31]. The present findings reveal crayfish from Okoro river estuary (24.47% ash) are a good source of mineral such as calcium, potassium and magnesium. Generally, proximate compositions of fish vary with species, season, age, environmental factors and feeding habit of the fish. Besides ash content, shrimp waste contains high mineral profile (> 26%) which could supply the required minerals for the formulation of fishmeal and animal feeds. Also shrimp waste can serve as mineral supplement for growing snails. Bone meal supplies minerals to culture fish and it is added at 0.5% or 1% of the ration. Thus, the total ash content in shrimp waste can substitute for the requirement of bone meal in feed formulation. The ash content in the samples is a reflection of the amount of the mineral contained in the samples. Consequently, crayfish from Okoro river estuary could be particularly useful for pregnant and lactating women and children, in view of their very rich mineral content.

Apart from being a major source of metabolic energy, lipids also supply essential fatty acids needed for the maintenance of the integrity of cellular membranes and serve as precursors of steroid and molting hormones [6].

The partitioning of food constituents as shown in the dendrogram (Fig. 2) is achieved by the hierarchical clustering of food compounds into categories based on the chemical properties of the compounds such that within-group variance is minimized ([32]. Hence, categories such as moisture, protein (Kjeldahl protein), crude lipid (soluble fat), crude fibre, ash content (inorganic mineral) and nitrogen-free extracts (digestible carbohydrates) are joined in a tree-like dendrogram showing a natural selection of the affinity of one proximate constituent to another [18]. The total distance between the relationships is a binary coefficient or merger determinant as indicated by the Euclidean distance (ED); the smaller the distance (ED) between cases, the greater the similarity [17]. Figure 2 show the proximate compositions are first reduced to three main subsets/clusters in which the ash and lipid contents exhibit closer affinity with the carbohydrate, protein and fibre subset (ED = 8.368) than with the dry matter/moisture subset (ED = 12.013).

CONCLUSION

Proximate mineral composition *Nematopaemon* shrimps are rich source of food nutrients and essential minerals. The study recorded high mineral content in exoskeleton (shell) samples than flesh portion. The results indicated that shrimps are good sources of protein and mineral supplement. *Nematopaemon* shrimps have nutritional superiority over other protein products and comparatively have low calories when compared with other protein sources. The study revealed that increased ash content was noticed in increased size groups and protein content was higher in younger shrimps than in adults. Shrimps are salient constituents of the Nigerian diet and they break the religious and ethnocentric barriers. Thus, it is therefore recommended for consumption by developing countries in Africa to alleviate the problem of nutrient and protein malnutrition in children. The delicacy could be taken as snacks or as part of the main meal. The conversion of the ash content of shrimps as an alternative source of high quality protein supply and feed formulation for children and animals is recommended. The results of the nutritive values of shrimps obtained from this study can provide nutritional data for dietary planning as well processing and preservation of fish products in Nigeria.

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