MINERAL SAFETY INDEX AND FUNCTIONAL PROERTY OF THE STOMATOPOD SHRIMP (*SQUILLA ACULEATA* HOLTHUIS, 1959) (CRUSTACEA: STOMATOPODA)

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ABSTRACT
The study was conducted to analyze the mineral composition, safety ratio and functional properties of the cephalothorax and abdomen (fillet) of the stomatopod shrimp, Squilla aculeata. The mineral content, expressed in mg 100g-1, revealed distinctive patterns in the two body parts. The cephalothorax exhibited higher concentrations of Ca, P, Mg, Na, K, Fe, and Mn compared to the abdomen. Notably, the mineral safety index (MSI) calculated for each mineral indicated potential mineral overload in both body parts, excluding sodium. The MSI values for Ca, Mg, P, and Na were compared against standard values. All minerals, except sodium, exhibited negative percentage differences, suggesting elevated concentrations beyond the recommended levels. The extent of these differences ranged from -1250.27 to 60.29 for cephalothorax and -706.2 to 82.82 for the abdomen, emphasizing the potential health risks associated with the consumption of S. aculeata. Furthermore, the functional properties of the stomatopod shrimp, revealing significant variations between the cephalothorax and abdomen. The cephalothorax demonstrated higher values in water absorption capacity (WAC), oil absorption capacity (OAC), emulsion stability, foam stability, solubility, packed bulk density, loose bulk density, specific gravity, and emulsion capacity. Conversely, the abdomen exhibited superior foam capacity, swelling power, and dispersibility. In conclusion, this study contributes valuable insights into the mineral safety/composition and functional properties of different body parts of S. aculeata. The findings underscore the importance of considering both nutritional content and functional characteristics when evaluating the suitability of stomatopod shrimp for consumption and industrial applications.

Keywords*:* **Food properties, mineral element, shrimp, stomatopod, Lagos lagoon, Nigeria**

INTRODUCTION

Marine shrimps dominate the production of crustaceans typically farmed in coastal aquaculture and are an important source of foreign-exchange earnings for a number of developing countries in Asia and Latin America (FAO, 2020). Stomatopod is found in coastal lagoons with muddy bottoms in intertidal and sub tidal high densities areas with suitable burrowing substrates in the Mediterranean Sea (Ragonese *et al*., 2012). It is a benthic species, strongly related to bottom sediments as demonstrated by its burrowing behaviour and by the composition of its diet (Mili *et al*., 2013; Sağlam *et al*., 2018). The stomatopod shrimp, *Squilla aculeata* is a crustacean of the order Stomatopoda, having a carapace that does not cover the posterior thorax and a broad abdomen bearing gills on the appendages.

In Nigeria, the stomatopod shrimp is still considered as a by catch in the trawl fisheries for shrimp and the trap fisheries for lobsters (Lawal-Are *et al*., 2018a). Edible crustaceans such as shrimp, 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 are eaten either whole or as flesh alone. 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 (Lawal-Are *et al*., 2018a). 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 (Moruf and Akinwunmi, 2022). Shrimps caught from fresh, marine and brackish waters and ponds of various types are becoming delicacies in Nigeria.

In present time, the best means to obtain the benefits of shrimp-consumption is to utilize its components as ingredients, such as shrimp protein isolates. The successful use of such protein ingredients depends upon their abilities to fulfill one or more functional requirements, e.g. good solubility, emulsion/foam stabilization, or gel formation (Hall *et al.*, 2017). These functional properties are intrinsic physicochemical characteristics, which affect the behaviour of properties in food systems during processing, manufacturing, storage and preparation (Moruf, 2021). Prior to this work, the mineral safety indices of stomatopods have not been evaluated. The present work is to examine the mineral safety index and functional profiling of the cephalothorax and abdomen of *S. aculeata*, a stomatopod from the Lagos Lagoon in Nigeria. This study will provide basic information to help evaluate the application for shrimps in food products.

MATERIALS AND METHODS

Sample collection and preparation

Wet samples of stomatopod, *S. aculeate* were obtained from commercial trawl catches at the landing site of the 2 km wide Lagos Harbour, between May and October, 2023. The sampling station lies along the eastern parts of the Lagos Harbour, which is at the mouth to the Atlantic Ocean. The shrimps were washed with distilled deionised water to remove any adhering contamination, drained and identified according to FAO identification guide (Schneider, 1990). The specimens were kept in ice-chest before being taken to Marine Sciences Department, University of Lagos, for further analysis.

Analytical procedures

The shrimp samples were dissected with clean stainless steel instruments, separating the cephalothorax from the abdomen. Both tissues were dried at 105^oC and homogenised. Using a flame photometer (model 405, corning, U.K), the macro minerals were determined. Mineral Safety Index was calculated according to formulae described by Hatcock (1985). Water absorption capacity (WAC) and oil absorption capacity (OAC) were determined by following the method described by Brishti *et al.* (2017). The 0.25 g of each shrimp tissue was mixed with 5 mL distilled water or oil in pre-weighed centrifuge tube for 30 secs using a vortex. Sample was allowed to stand at room temperature (20 - 25^oC) for 15 min and centrifuged at 3000 rpm for 15 min. After centrifugation, the supernatant was decanted, and the centrifuge tubes + precipitate were re-weighed. The modified methods reported by Souissi *et al.* (2007) were used to determine the emulsion capacity and emulsion stability. Foam capacity and stability (% FS) as determined by the aeration method proposed by Pacheco- Aguilar *et al.* (2008). The bulk density was analyzed following the method of Asoegwu *et al.* (2006) and functional dispersibility was evaluated according to Lee and Lian (2002). Swelling power and solubility were determined by following the method described by Pranoto *et al.* (2014) with slight modification. Protein solubility expressed as:

$$Solubility = \frac{\text{Protein content in supernatant}}{\text{Total protein in sample}} \text{x } 100\%.$$

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, percentage difference and coefficient of variation.

RESULTS AND DISCUSSION

Mineral Composition and Safety Index

The variations in the mineral composition of cephalothorax and abdomen (fillet) of *S. aculeata* are shown in Table 1. The mineral composition in mg 100g^{-1} of cephalothorax was Ca (16203.21 ± 102.96), P (2634.26 ± 55.05), Mg (623.67 ± 53.86), Na (198.56 ± 13.66), K (253.46 ± 2.93), Fe (39.68 ± 2.87) and Mn (522.75 ± 29.99) while the mineral composition in Mg 100g^{-1} of abdomen of the shrimp was Ca (9674.45 ± 301.62), P (2794.45 ± 353.25), Mg (311.73 ± 23.24), Na (85.9 ± 3.15), K (80.94 ± 8.2), Fe (47.96 ± 3.24) and Mn (485.68 ± 23.52). The pattern of mineral contents in the cephalothorax of *S. aculeate* was Ca > P > Mg > Mn > K > Na > Fe, while for the abdomen, it was Ca > P > Mn > Mg > Na > K > Fe. The values of Ca, Mg, Na and K of the cephalothorax were significantly higher than the values obtained in the abdomen of the shrimp. The result conforms to the report of Wardiatno *et al.* (2012), which indicates that the mantis shrimps can be a good source of macro minerals (Na, K, Ca and Mg) and of micro mineral (especially Zinc) for human health.

Table 1: Mean Variations in the Mineral Contents of the Stomatopod Shrimp, *Squilla aculeata*

Mineral (mg/100g)	Cephalothorax	Abdomen	*P-Value*
Calcium	16203.21 ± 102.96	9674.45 ± 301.62	0.00*
Phosphorus	2634.26 ± 55.05	2794.45 ± 353.25	0.68
Manganese	522.75 ± 29.99	485.68 ± 23.52	0.39
Magnesium	623.67 ± 53.86	311.73 ± 23.24	0.01*
Potassium	253.46 ± 2.93	80.94 ± 8.2	0.00*
Sodium	198.56 ± 13.66	85.9 ± 3.15	0.00*
Iron	39.68 ± 2.87	47.96 ± 3.24	0.13

*Significant difference

The values of the mineral safety index (MSI) in the Stomatopod Shrimp, *S. aculeate* are shown in Table 2. 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 (except sodium) had MSI calculated values higher than the MSI tabulated, thereby showing negative percentage differences, ranging from -1250.27 to 60.29 and -706.2 to 82.82 for cephalothorax and abdomen samples respectively. The result indicates that the consumption of Stomatopod Shrimp, *S. aculeate* from the study area will cause mineral overload (with the exception of sodium). Thus, the possibility of secondary hypertension. Contrary to the report on the caridean species, *Macrobrachium macrobrachion* where its consumption would not constitute mineral overload (Moruf and Akinwunmi, 2022).

Table 2: Mineral Safety Index (MSI) in the Stomatopod Shrimp, *Squilla aculeata*

Mineral	MSItv	Cephalothorax		Abdomen		Mean	SD	CV%
		MSIcv	%D	MSIcv	%D			
Calcium	10	135.03	-1250.27	80.62	-706.2	107.82	38.47	35.68
Magnesium	15	23.39	-55.92	11.69	22.07	17.54	8.27	47.16
Phosphorus	10	21.95	-119.52	23.29	-132.87	22.62	0.94	4.17
Sodium	4.8	1.91	60.29	0.82	82.82	1.37	0.76	56.01

Keys: MSIcv= Calculated value of Mineral Safety Index, MSItv= Tabulated value of Mineral Safety Index, SD= Standard deviation, %D= Percentage Difference, CV%= Coefficient of variation

Functional properties

Table 3 shows the functional properties of the stomatopod shrimp. Relatively, higher range values of WAC (105.65±0.48 %), OAC (47.08±0.06 %), emulsion stability (36.50±0.05 %), foam stability (35.00±0.03 %), solubility (2.34±0.06 %), packed bulk density (0.86±0.03 g/ml), loose bulk density (0.61±0.02 g/ml), specific gravity (0.67±0.02 g/ml) and emulsion capacity (2.45±0.36 ml/g) were recorded in the cephalothorax. However, foam capacity (3.66±0.25 %), swelling power (310.36±5.45 %) and dispersibility (10.20±0.25 %) were higher in the abdomen. The recorded functional properties in the different parts of the stomatopod shrimp showed significant difference in WAC, OAC, foam stability, swelling power, dispersibility, loose bulk density and specific gravity. The absorption capacities are lower than WAC (198.13±3.08 %) and OAC (292.59±2.07 %) reported for periwinkle from the same water body (Lawal-Are *et al.*, 2018b). WAC reflects the extent of denaturation of the protein while OAC acts as a flavour retainer and improves the mouth feel of foods (Butt and Batool, 2010). Accordingly, WAC is affected by pH and ionic strength while OAC depend on the amount of non-polar amino acids in the side chain and structure of the proteins (Lone *et al.*, 2015).

There are few reports in the literature on functional properties of shrimp that can serve as a comparison: Moruf *et al.* (2021) reported better functional properties in the exoskeleton sample of *Farfantepenaeus notialis,* while the flesh sample had a significantly ($P < 0.05$) higher percentage of swelling power (111.9 ±0.01%). A higher emulsion capacity in raw crabmeat compared with Pacific whiting (*Merluccius productus*) (Pacheco-Aguilar *et al.,* 2008). In this study, the foaming capacities and stabilities are in close agreement with the foaming capacity of *Tympanotonos fuscatus* (6.90%) (Moruf, 2021) and foaming stability of raw cuttlefish (46%) (Lawal-Are *et al*., 2018b). According to Lone *et al.* (2015), foamability is an important food property by which proteins form a flexible cohesive film to entrap air bubbles. The low bulk density in this present study would be an advantage in the formulation of complementary foods.

Table 3: Functional Properties of the Stomatopod Shrimp, *Squilla aculeata*

Parameters	Cephalothorax	Abdomen	*P*-Value
Water Absorption Capacity (%)	105.65±0.48	80.86±0.02	0.00*
Oil Absorption Capacity (%)	47.08±0.06	45.09±0.06	0.00*
Emulsion Stability (%)	36.50±0.05	36.40±0.02	0.13
Foam Capacity (%)	3.26±0.40	3.66±0.25	0.44
Foam Stability %	35.00±0.03	31.00±0.02	0.00*
Swelling Power %	213.05±0.58	310.36±5.45	0.00*
Solubility %	2.34±0.06	2.33±0.06	0.91
Dispersibility %	8.60±0.40	10.20±0.25	0.03*
Packed Bulk Density (g/ml)	0.86±0.03	0.82±0.01	0.27
Loose Bulk Density (g/ml)	0.61±0.02	0.46±0.02	0.01*
Specific Gravity (g/ml)	0.67±0.02	0.56±0.01	0.01*
Emulsion Capacity (ml/g)	2.45±0.36	2.40±0.16	0.91

*Significant difference

CONCLUSION

The study found that the concentrations of important minerals in the Stomatopod Shrimp, *Squilla aculeata* varied with respect to body parts. The cephalothorax had appreciable levels of minerals, whereas the abdomen will be highly desirable for preparing comminuted sausage products due to the better functional qualities.

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