

Functional properties of the Guinean Mantis Shrimp, *Squilla aculeata*: Holthuis 1959 (Crustacea: Stomatopoda) from the Lagos Lagoon in Nigeria

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Abstract

Shrimp proteins, while contributing to the nutritional value of foods, can also be used as additives; their interesting functional properties reflect their physico-chemical characteristics, composition and structure. The aim of this study was to determine the oleic acid content and functional properties of the Guinean Mantis Shrimp, *Squilla aculeata* using standard methods. The rank profile of colour attributed to cephalothorax and abdomen of the *Squilla aculeata* followed the pattern lightness > yellowness > redness. The level of oleic acid in cephalothorax (3.41%) was higher than the percentage value in the abdomen (2.94%), although this was not observed to be significantly different. Relatively, higher values of water absorption capacity (105.65±0.48%), oil absorption capacity (47.08±0.06%), emulsion stability (36.50±0.05%), foam stability (35.00±0.03%), protein 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 part. Both shrimp parts, especially cephalothorax will be highly desirable for preparing comminuted sausage products due to the better functional qualities.

Keywords: Food properties, oleic acid, shrimp, stomatopod, Lagos lagoon

Propriétés fonctionnelles de la crevette de la mante guinéenne, *Squilla aculeata*: Holthuis 1959 (crustacée: stomatopoda) de la lagune de Lagos au Nigeria



Résumé

Les protéines de crevettes, tout en contribuant à la valeur nutritionnelle des aliments, peuvent également être utilisées comme additifs; Leurs propriétés fonctionnelles intéressantes reflètent leurs caractéristiques, la composition et la structure physico-chimiques. Le but de cette étude était de déterminer la teneur en acide oléique et les propriétés fonctionnelles de la crevette de la mante guinéenne, *Squilla aculeata* utilisant des méthodes standard. Le profil de classement de la couleur attribuée au céphalothorax et à l'abdomen de la *Squilla aculeata* a suivi la légèreté de motif > jaunement > rougissement. Le niveau d'acide oléique dans le céphalothorax (3,41%) était supérieur à la valeur en pourcentage dans l'abdomen (2,94%), bien que cela ne soit pas observé comme étant significativement différent. Relativement, des valeurs plus élevées de capacité d'absorption d'eau (105,65 ± 0,48%), capacité d'absorption d'huile (47,08 ± 0,06%), stabilité de l'émulsion (36,50 ± 0,05%), stabilité en mousse (35,00 ± 0,03%), solubilité protéique (2,34 ± 0,06%), densité en vrac emballée (0,86 ± 0,03 g/ml), densité en vrac lâche (0,61 ± 0,02 g/ml), gravité spécifique (0,67 ± 0,02 g/ml) et capacité d'émulsion (2,45 ± 0,36 ml/g) ont été enregistrées dans le céphalothorax. Cependant, la capacité de mousse (3,66 ± 0,25%), la

puissance de gonflement ($310,36 \pm 5,45\%$) et la dispersibilité ($10,20 \pm 0,25\%$) étaient plus élevées dans la partie abdominale. Les deux parties de crevettes, en particulier le céphalothorax seront très souhaitables pour préparer des produits de saucisses comminustés en raison des meilleures qualités fonctionnelles.

Mots-clés: propriétés alimentaires, acide oléique, crevettes, stomatopodes, lagon de Lagos.

Introduction

Aquatic food system strategies can help address the complex issue of the “triple burden of malnutrition”; food insecurity, under nutrition and overweight (FAO, 2020). Aquatic foods include finfish, crustaceans, molluscs and aquatic plants such as seaweed. Many coastal and inland populations rely on these aquatic foods as the most accessible source of animal protein. 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). Marine shrimp culture has become a lucrative activity in several countries. In Nigeria, stomatopod has been reportedly found in Lagos Lagoon and its adjacent creeks (Lawal-Are *et al.*, 2018a). The Guinean Mantis 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. 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 (Ragonese *et al.*, 2012). Shrimps caught from fresh, marine and brackish waters and ponds of various types are becoming delicacies in Nigeria. They are eaten either whole or as flesh alone. In present time, the best means to obtain the benefits of crustacean-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 physico-chemical characteristics which affect the behaviour of properties in food systems during processing, manufacturing, storage and preparation (Eltayeb *et al.*, 2011; Moruf, 2021). Prior to this work, the functional properties of stomatopod have not been evaluated. The present work is to examine the oleic acid content and functional properties of the cephalothorax and abdomen of *S. aculeata*, a stomatopod from the Lagos Lagoon in Nigeria. This study will provide some basic information to help evaluate the application for shrimp protein isolates in food products.

Materials and methods

Sample collection and preparation

Wet samples of stomatopod, *S. aculeata* were obtained from commercial trawl catches at the landing site of the 2km wide Lagos Harbour, between May and October, 2021. 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 de-ionised 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°C and homogenised. 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°C) 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 WAC and OAC were expressed as seen in equation 1.

$$\text{WAC or OAC (g/g)} = \frac{W_2}{W_1} \dots \dots \dots (1)$$

Where W1 = weight of the dry sample (g)
 W2 = weight of precipitate + centrifuge tube (g)

The modified methods reported by Souissi *et al.* (2007) were used to determine the emulsion capacity and emulsion stability. Foam capacity as determined by the aeration method proposed by Pacheco-Aguilar *et al.* (2008). Protein mixture was aerated using a Sorvall Omni Mixer with macro-attachment assembly (Norwalk, CT, U.S.A). The FC was expressed as percent increase after aeration. Volumes were recorded before and after aeration (equation 2) as;

$$\text{Foam capacity (\%)} = \frac{\text{Volume after aeration} - \text{Volume before aeration}}{\text{Volume before aeration}} \times 100\% \dots (2)$$

Foam stability (% FS) was calculated as the percentage of foam remaining after 10, 30, 60, and 90 min inactive periods while specific gravity was determined according to weight under water method as described by Solaiman *et al.* (2015). The bulk density was analyzed following the method of Asoegwu *et al.* (2006) and calculated using equation 3:

$$\text{Bulking density} = \frac{\text{Weight of sample (g)}}{\text{Volume of sample (ml)}} \dots \dots \dots (3)$$

The functional dispersibility was evaluated according to Lee and Lian (2002) as the ease of dispersing the thawed mince (300 g) during mixing for 1 min in a Kitchen-Aid bowl mixer. Swelling power and solubility were determined by following the method described by Pranoto *et al.* (2014) with slight modification. A sample (0.2 g) was put in a pre-weighed centrifuge tube, added with 10 mL distilled water and mixed using vortex. The sample was allowed to stand at room temperature (20-25°C) for 5 min and then put in a water bath at 95°C for 30 min. After that, it was cooled at 20-25°C for 10 min. The sample was centrifuged at 3000 rpm for 15 min to separate gel and supernatant. The gel after separating from supernatant was expressed as swelling power while the supernatant is placed on a plate that has been known to weigh and then dried in an oven to a constant weight. Swelling power was calculated by using equations 4.

$$\text{Swelling power (g/g)} = \frac{W_2 - W_1}{W_0} \dots \dots \dots (4)$$

Where W0 = weight of the dry sample (g),
 W1 = weight of the dry sample + centrifuge tube (g),
 W2 = weight of gel + centrifuge tube (g)

In the determination of solubility, sample (200 mg) was dispersed in 20 mL buffers of pH 3.0. The buffer mixture was stirred with a magnetic stir bar at room temperature for 30 min and centrifuged at 7500 x g (4 °C) for 15 min. Protein content of the supernatant and total protein in sample were determined using the bicinchoninic acid protein assay (BCA) method with bovine serum albumin as a standard following manufacture protocol.

Protein solubility expressed as seen in equations 5:

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$$\text{Solubility (\%)} = \frac{\text{Protein content in supernatant} \times 100\%}{\text{Total protein in sample}} \dots (5)$$

Statistical analysis

Data obtained was subjected to analysis of variance (ANOVA). Microsoft Excel 2010 was used to perform descriptive statistic and t-test to sort out the differences in two means at a significant level of $P < 0.05$.

Results and discussion

Colour intensity of guinean mantis shrimp

The rank profile of colour attributed to cephalothorax and abdomen of the *S. aculeata* followed the pattern lightness > yellowness > redness (Figure 1). The highest values of yellowness (28.65) and redness

(10.62) were obtained in cephalothorax samples while highest value of lightness (70.62) was recorded in abdomen samples. However, the differences among the colour intensities between the shrimp parts were not significantly ($P < 0.05$). Lawal-Are *et al.* (2020) reported similar colour attribute for mince and whole jumbo lump of *Portunus validus*. Seafood consumers consider colour as a quality indicator, hence colour attribute is an important quality parameter in fish restructured products. According to Font-i-Furnols and Guerrero (2014), color is the single most important driving factor in a consumer's decision to purchase meat.

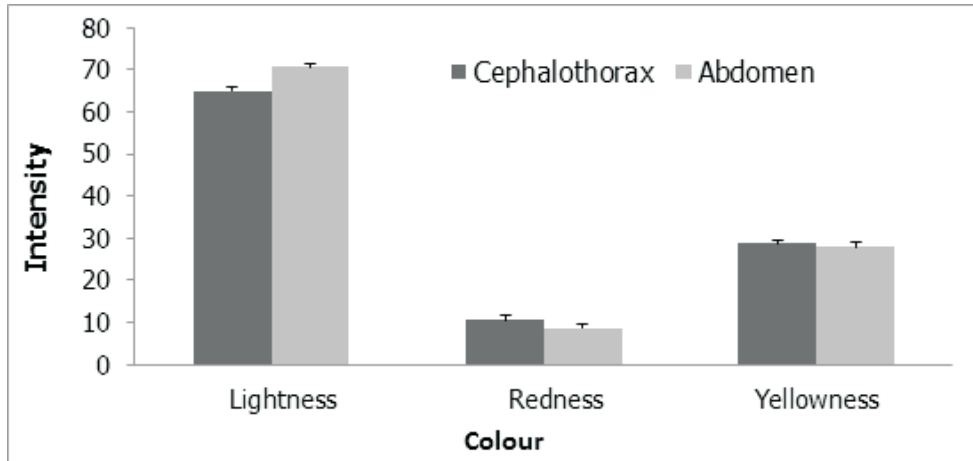


Figure 1: Colour intensity of the Guinean Mantis Shrimp, *Squilla aculeata*

Free fatty acid content

Figure 2 shows free fatty acid (FFA) content as oleic acid in the Guinean Mantis Shrimp, *S. aculeata*. The % FFA level in cephalothorax (3.41%) was higher than the percentage value in the abdomen (2.94%), although this was not observed to be significantly different. This is lesser to the

percentage concentration of oleic acid (17.62 ± 0.04 %) recorded in the Lagoon Crab, *Callinectes amnicola* (Moruf and Lawal-Are, 2019). According to Sales-Campos *et al.* (2013), oleic acid is a type of fatty acid, which improves heart conditions by lowering cholesterol and reducing inflammation.

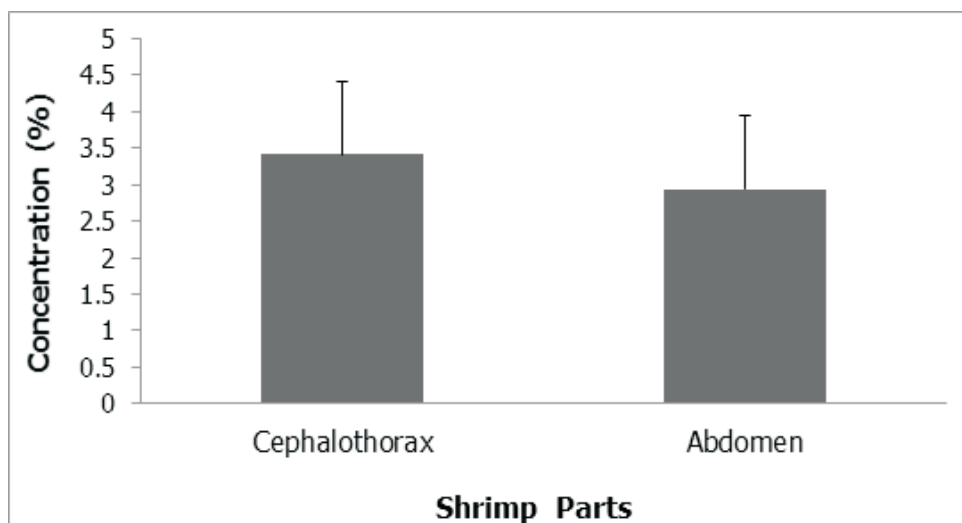


Figure 2: Free Fatty Acid (as Oleic) in the Guinean Mantis Shrimp, *Squilla aculeata*

Functional properties

Table 1 shows the functional properties of the Guinean Mantis 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 Guinean Mantis 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.*, 2021). 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 shellfish that can serve as a comparison. Moruf *et al.* (2021a) 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 grilled *Cardisoma armatum* (Moruf *et al.*, 2021b) and 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 1: Functional properties of the Guinean Mantis 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 showed that the Guinean Mantis Shrimp, *Squilla aculeate* was a good source of free fatty acid (oleic acid) with attractive colour attributes. Both shrimp parts, especially cephalothorax could be desirable for preparing comminuted sausage products due to its functional qualities.

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