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Full Length Research Paper

Nutrient and energy composition of flesh, limbs and carapace of *Callinectes amnicola* (Blue Crab) from Great Kwa river, South East Nigeria

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ABSTRACT

This study compared some nutrient and energy levels in three body parts of *Callinectes amnicola* using AOAC methods. Fresh crab specimens were collected from Great Kwa River landing site in Calabar-Nigeria. Results showed that *C. amnicola* is rich in nutrients, which were unevenly distributed across the body parts. For proximate, moisture was the most predominant (71.50±0.10g/100g-81.40±0.01g/100g), the dry matter representing about one-fourth the total body weight. Protein and fat recorded highest values in the flesh (36.30±0.01g/100g and 24.54±0.02g/100g, respectively) and least in the carapace (30.30±0.02g/100g and 12.59±0.01g/100g, respectively) (*p*<0.05). On the contrary, the flesh had the lowest carbohydrate (29.82±0.02g/100g), ash (7.26±0.02g/100g) and fibre (1.91±0.01g/100g) contents, which showed highest values in the carapace (40.10±0.10g/100g, 13.17±0.02g/100g and 3.70±0.10g/100g, respectively). Energy value was generally low (4.50±0.09kcal/g-5.79±0.36kcal/g). For minerals, sodium (139.25±0.36mg/100g-154.46±0.08mg/100g) and calcium (105.46±0.01mg/100g-143.53±0.06mg/100g) were the most predominant. The micro-mineral elements iron and zinc also occurred in appreciable quantities, with the highest contents in the flesh (16.42±0.10mg/100g and 4.47±0.06mg/100g, respectively) and lowest in the carapace (9.56±0.06mg/100g and 2.53±0.12mg/100g, respectively). The flesh, limbs and carapace of *C. amnicola* are a significant source of nutrients. Toxicological and biological investigation should consider possible use of powdered nutritious exoskeleton of *C. amnicola* as nutraceutical agent.

Keywords: Crab, proximate composition, energy, mineral, nutraceutical.

INTRODUCTION

Globally, the demand and consumption of aquatic foods has increased rapidly due primarily to their acclaimed health promoting characteristics. Fish and shellfish are the two principal groups of aquatic resources used in the human diet. They are among the few foods that still come mostly from the wild. Shellfish are hard body aquatic organisms such as crabs, prawns, shrimps, lobsters, mussels and oysters. Crabs belong to the group of shellfish called crustaceans, identified by their hard shells and ten appendages or legs: hence, they are decapods. It has been reported that crabs and other crustaceans account for about one-fifth or 20g/100g of all the foods obtained from the seas, rivers, lakes, and other aquatic sources (Udo and Arazu, 2012). Also, crabs alone make up about 20g/100g of all marine crustaceans consumed worldwide (Elegbede and Fashina-Bombata, 2013). Over 100 species of crab are known worldwide with blue crabs being the most commonly consumed (Omotayo *et al*., 2013). Crab is used in a wide variety of dishes including salads, soups, pates, starters, or served as a main course. The taste, texture and nutritional benefits of crab meat make it a versatile delicacy all over the world.

The crab meat is nutritionally valuable as a rich source of high quality protein, minerals and vitamins (Adeyeye, 2002; Skonberg and Perkins, 2002; Omotayo *et al*., 2013) with low levels of fat and carbohydrates (Udo and

Arazu, 2012). A report of the Shellfish Association of Great Britain shows that the protein in shellfish is high in essential amino acids and is highly digestible because of the lack of connective tissue (SAGB, 2009). The minerals found in abundance in crab include calcium, copper, zinc, phosphorus and iron (Adeyeye, 2002), with less amounts of chromium and selenium. Crab is also a rich source of fat-soluble vitamins A, D and E (Dias *et al*., 2003) and a number of B vitamins (Holland *et al*., 1993). The lipids in crabs constitute a major source of highly unsaturated fatty acids especially the omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (IOM, 2006).

A number of studies have linked the health benefits of crab meat to its high content of omega-3 fatty acids, which the crab obtains from phytoplanktons and algae in its natural habitat. Research has shown that omega-3 fatty acids help in the prevention and control of many non-communicable diseases including obesity, diabetes mellitus, cancer, arthritis, hypertension and heart disease (SAGB, 2009; Defilippis *et al*., 2010; Wilk *et al*., 2012). In fact, studies (Roth and Harris, 2010; Nodari *et al*., 2011) show that a diet rich in omega-3 fatty acids improves the ratio of high density lipoprotein (HDL) to low density lipoprotein (LDL) cholesterol, a ratio used by many heart specialists to predict the risk of heart disease. In recognition of their cardioprotective effect, the American Heart Association has recommended omega-3 fatty acids mainly from sea foods as part of the dietary approaches to prevent and treat hypertension (Appel *et al*., 2006).

Protein energy malnutrition is widespread in Nigeria (Ubesie and Ibeziakor, 2012) and micronutrient deficiency particularly those of vitamin A, iron, zinc and iodine are also common (Maziya-Dixon *et al*., 2004). This is coupled with emerging epidemics of diet-related non-communicable diseases such as obesity, diabetes, cancer, hypertension, heart disease and atherosclerosis among Nigerians. Dietary deficiencies can be minimized by increased consumption of protein-rich foods especially from animal sources. However in Nigeria, conventional animal protein food sources such as cow, goat and chicken are inadequate and often beyond the economic reach of most households. Crab has become one of the chief sources of animal protein to the low- and high-income earners due to its low price, high market availability, and copious health benefits (Adeyeye, 1996).

Many crab species are consumed in various parts of the world including Nigeria. A number of studies have been carried out to document the nutrient composition of crabs but literature on the nutrient composition of crabs is still incomplete. Also, available reports suggest that the chemical composition of crabs varies greatly among species and from an individual crab to another, depending on age, sex, environment, and season (Petricorena, 2014).

Again, preparing crab for consumption includes the removal and discarding of the hard parts such as the carapace. Also during crab consumption, the remaining exoskeleton/hard parts not removed during food preparation are usually discarded by the consumer. This study was designed to compare the nutrient composition of the edible and non-edible (hard) parts of crab and to investigate the effect of continuous exclusion of the hard parts of crab from human diets. Hence, we determined and compared the proximate, energy and mineral composition of the flesh, limbs and carapace of the marine blue crab (*Callinectes amnicola*) obtained from the great Kwa River, South East Nigeria.

MATERIALS AND METHODS

Sample collection

Thirty (30) fresh matured lively specimens of *Callinectes amnicola* (marine blue crab) were purchased from fishermen at the landing site of the Great Kwa River in November 2014. This river is located between latitudes 40^o 45´ and 50^o 15´N and longitudes 80^o 15´ and 80^o 30´E with an estimated length of 56km and width of 2.8km. The specimens were placed in an ice chest and immediately transported to the Research laboratory in the Department of Biochemistry, University of Calabar.

Preparation for analyses

The fresh crabs were washed in running tap water after which the different body parts: carapace, limbs and flesh were separately removed. Each group of body parts was dried in an electric oven at 105^oC for 24 hours. The dried body parts were afterwards ground in an electric blender, packed in airtight plastic bottles and stored in the refrigerator at 4^oC pending chemical analysis within 48 hours.

Proximate analysis

The proximate composition of the carapace, limbs and flesh was determined by the method of the Association of Official Analytical Chemists (AOAC, 2005). Moisture content was taken as the weight loss after drying 2g of each fresh body part to a constant weight at 87-98°C with the aid of an electric oven (Astell Heason, England) for 24 hours. Crude protein was determined by the micro-Kjeldahl method in which the total nitrogen in the sample was estimated and subsequently multiplied by a factor of 6.25. Fat content was obtained by acid hydrolysis and intermittent extraction with petroleum ether (B. P. 40-60°C) using Soxhlet apparatus (Corning, England). Ash was determined by dry ashing or by measuring the residue left after incineration of a weighed portion of the sample at 600°C for 10 hours using a muffle furnace.

Table 1. Proximate constituents in different body parts of *Callinectes amnicola* (g/100g dry matter)

	Moisture	Ash	Protein	Fat	Crude fibre	Carbohydrate
Flesh	81.40±0.06	7.26±0.01	36.30±0.06	24.54±0.01	1.91±0.01	29.82±0.01
Limbs	79.50±0.06*	7.87±0.01*	34.63±0.03*	18.57±0.01*	2.81±0.01*	35.98±0.01*
Carapace	71.43±0.03*,a	13.17±0.01*,a	30.30±0.02*,a	12.63±0.04*,a	3.70±0.01*,a	40.10±0.06*,a

Values are expressed as mean ±SEM, n = 3.
* = significantly different from flesh at $p<0.05$
a = significantly different from limbs at $p<0.05$

Crude fibre was estimated by boiling the sample with 1.25% (w/v) sulphuric acid and then with 1.25% (w/v) sodium hydroxide and incinerating the residue at 550°C; the loss in weight represented the crude fibre content of the sample (AOAC, 2005). Total carbohydrate content was obtained by difference after subtracting the moisture, protein, fat and ash from the total dry matter, expressed in percentage.

Determination of energy value

The caloric value, expressed as kcal/g of each body part was calculated using the Atwater factors for protein, fat, and carbohydrate (Atwater & Bryant, 1900). Accordingly, the amount of protein obtained by chemical analysis was multiplied by 4, fat was multiplied by 9, and digestible carbohydrate was multiplied by 4. Energy was calculated as the sum of the three values. That is, Energy = [protein (x 4) + fat (x 9) + carbohydrate (x 4)] kcal/g.

Determination of mineral elements

Elemental composition was analysed using the solution obtained by dry-ashing the samples at 550°C and dissolving in distilled water with a few drops of concentrated hydrochloric acid in a volumetric flask. Sodium (Na) and potassium (K) were measured with a Corning U.K. Model 405 flame photometer (AOAC, 2005) while iron (Fe), Zinc (Zn), magnesium (Mg) and calcium (Ca) were obtained spectrophotometrically (AOAC, 2005).

Statistical analysis

The results obtained were subjected to one-way analysis of variance (ANOVA) using the statistical package for social sciences (SPSS) 2009 (version 17.0). Statistical significance was accepted at 5% probability level.

RESULTS

Proximate composition

The proximate composition of the different body parts expressed as g/100g dry matter are presented in Table 1. The moisture content ranged from 71.50±0.10g/100g in the carapace to 81.40±0.01g/100g in the flesh. Similarly, protein and fat showed highest values in the flesh (36.30±0.01g/100g and 24.54±0.02g/100g, respectively) and least values in the carapace (30.30±0.02g/100g and 12.59±0.01g/100g, respectively) (p<0.05). In contrast, the flesh had the lowest contents of carbohydrate (29.82±0.02g/100g), ash (7.26±0.02g/100g) and crude fibre (1.91±0.01g/100g), which showed highest amounts in the carapace (40.10±0.10g/100g, 13.17±0.02g/100g and 3.70±0.10g/100g, respectively) (p<0.05).

Energy value

Figure 1 shows the energy values (mean ±SEM Kcal/g) of the three body parts. The results indicate that the carapace had the highest energy value (5.79±0.36kcal/g) followed by the limbs (4.85±0.36kcal/g), while the flesh recorded the lowest energy value (4.50±0.09kcal/g) ($p<0.05$).

Mineral composition

Table 2 presents the mineral contents of the different body parts. All the samples showed appreciable quantities of the six minerals estimated. Sodium was the most predominant (139.25±0.36mg/100g-154.46±0.08mg/100g) of the minerals followed by calcium (105.46±0.01mg/100g-143.53±0.06mg/100g). The flesh recorded the highest levels of all the minerals except calcium, which occurred most in the carapace (143.53±0.06mg/100g) followed by the limbs (140.33±0.10mg/100g) ($p<0.05$).

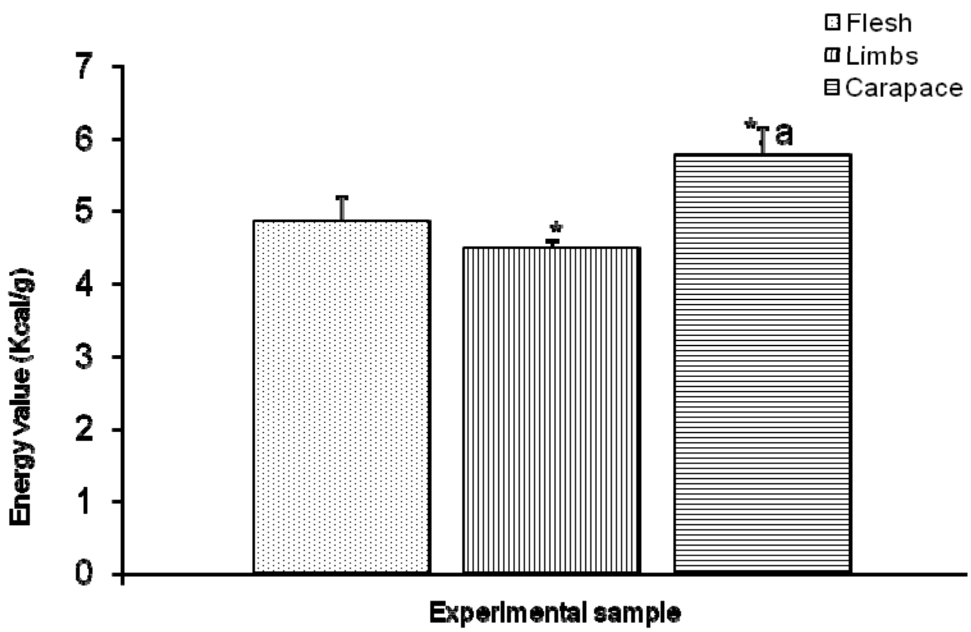

Figure 1. Energy values of flesh, limbs and carapace of *Callinectes amnicola*

Values are mean±SEM of 3 determinations
*** = signicantly different from flesh at $p<0.05$**
a = signicantly different from limbs at $p<0.05$

DISCUSSION

This study sought to investigate the levels of nutrients in three body parts (flesh, limbs, carapace) of *Callinectes amnicola*. The results showed some significant differences in the levels of nutrients across the parts analysed. Such differences across body parts have been reported in crabs and other crustaceans (Udo and Arazu, 2012; Ekpenyong *et al*., 2013). For the proximate constituents, moisture, protein and fat were more predominant in the flesh than in the other body parts. The high levels of moisture observed in this study are consistent with those reported by other workers for crabs of the same (Moronkola *et al*., 2011; Udo and Arazu, 2012) and other species (Skonberg and Perkins, 2002; Kelley *et al*., 2007; Kathirvel *et al.,* 2014; Omotayo *et al*., 2014). These results are an indication that fresh crabs have poor keeping quality and require immediate drying or processing to enhance their storing capability.

The results of this study further reveals that the blue crab is a rich source of protein. This is in line with several reports that crabs are high in protein and could be used to combat protein malnutrition much like the conventional animal protein sources like cattle, goat and chicken (Udo and Arazu, 2012; Omotayo *et al*., 2013). However, the mean crude protein contents recorded by the different body parts in this study are higher than the values (19.80%-28.00%) reported by Moronkola *et al*. (2011) for the same crab species. The observed differences in protein levels could be due to physiological, environmental or seasonal differences, which as reported by Petricorena (2014) are the usual factors that may cause variation in the chemical composition of crabs. These factors could also probably account for the observed differences in the levels of fat and other nutrients between this study and others. For instance, the body parts in this study showed higher levels of total fat than the levels reported by Moronkola *et al.* (2011) for *C.*

Table 2. Mineral composition of different body parts of *Callinectes amnicola* (mg/100g dry matter)

	Sodium	Potassium	Calcium	Magnesium	Iron	Zinc
Flesh	154.46±0.08	27.07±0.02	105.46±0.01	19.68±0.13	16.42±0.10	4.47±0.06
Limbs	149.52±0.09*	23.59±0.07*	140.33±0.10*	14.47±0.09*	13.54±0.31*	3.74±0.13*
Carapace	139.25±0.36*,a	14.48±0.11*,a	143.53±0.06*,a	12.68±0.14*,a	9.56±0.06*,a	2.53±0.12*,a

Values are expressed as mean ±SEM, n = 3.
* = significantly different from flesh at $p<0.05$
a = significantly different from limbs at $p<0.05$

amnicola and by Udo and Arazu (2012) for *C. amnicola* and *Uca tangeri*.

The results of the present study also reveal low energy values for the different body parts of *C. amnicola*. This is consistent with the reports by other workers (Ravichandran *et al*., 2009) that crustaceans are generally low in energy, making them a very healthy choice of food. The carapace had a significantly higher energy value than the other two body parts studied. A similar observation was reported by Ekpenyong *et al*. (2013) in their studies on another shellfish (prawn: *Macrobrachium macrobranchion*), which they attributed to the presence of chitin a linear polysaccharide in the exoskeleton. High content of chitin has been reported in crabs and other seafoods (Kurita, 2006; Ifuku *et al*., 2009). The same must have probably accounted for the higher energy value in the carapace observed in this study.

This study also shows that the different body parts of *C. amnicola* constitute a rich source of important macro- and micro-mineral elements. This is in line with the findings of other studies (Gokoglu and Yerlikaya, 2003; Naczk *et al*., 2004; Soundarapandian *et al*., 2014) that crab meat is an excellent source of minerals, particularly calcium, potassium, iron, zinc and phosphorus. In this study, sodium and calcium showed maximum levels in all the body parts studied. Soundarapandium *et al*. (2014) had made a similar observation in their studies on another edible crab species (*Podophthalmus vigil* Fabricius), irrespective of sex differences. Nevertheless, some variations do exist between the mineral contents recorded in this study and those of other studies (Udo and Arazu, 2012; Omotayo *et al*., 2013). It has been reported that variations in the mineral composition of marine foods are closely related to seasonal and physiological differences, area of catch, food source, and other environmental conditions (Soundarapandian *et al*., 2014). It is possible that these factors were also responsible for the observed differences in mineral composition between the present study and others.

This study reveals that the different body parts of *Callinectes amnicola* are rich in nutrients. In order to fully utilize the nutrients, it is suggested that the carapace and other hard body parts of *C. amnicola* should be blended together into a nutraceutical that could have a wide range of applications.

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