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PROXIMATE AND MINERAL COMPOSITION OF WHOLE BODY, FLESH AND EXOSKELETON OF MALE AND FEMALE COMMON WEST AFRICAN FRESH WATER CRAB *SUDANANAUTES AFRICANUS AFRICANUS*

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The proximate and mineral composition of the whole body (edible parts), flesh and exoskeleton of the male and female common West African fresh water crab *Sudananautes africanus africanus* were determined on a dry weight basis. In the exoskeleton and flesh, the protein, fat, the percentage utilizable energy due to protein and metabolizable energy were all of higher concentration in male than in female. Among the three samples the trace elements of Co, Fe, Ni, Mn and Zn were reasonably concentrated but Cu was not detected. In all the samples the Ca/P ratio was poor with values that ranged from 0.08 to 0.20 whereas that of Na/K was high with values of 0.86 to 1.35. $F_{calculated} > F_{table}$ at $p<0.05$ in proximate composition of male and female in exoskeleton, flesh, whole body; in mineral composition in male and female in exoskeleton, flesh, whole body; and in the mineral ratio in the flesh of male and female samples.

INTRODUCTION

Crabs are found throughout the world, chiefly in marine waters, but they also inhabit fresh water and land, where they dig or inhabit burrows.

Several crabs are prized as food. They include the Alaska king crab (*Paralithodes camtschatica*); the blue crab (*Callinetes sapidus*), which is the commercially important crab occurring along the East and Gulf coasts of the United States; the Dungenes crab (*Cancer magister*), which are present in Europe: non–swimming crabs used as food [Bulloug, 1958]; the giant mangrove swimming crab (*Scyllia serrata*) which is popular in pacific waters from the East Coast of Africa to India and as far away Japan [Muller & Tobin, 1980]. Soft-shelled crabs are newly moulted crabs whose new shells have not yet hardened.

The crab is usually consumed by individuals and it is often recommended for pregnant women. Literature is available on the chemical composition of the nutritionally valuable parts of male and female common West African fresh water crab *Sudananautes africanus africanus* [Adeyeye, 2002]; as well as on the relationship in the amino acid of the whole body, flesh and exoskeleton of the male crab [Adeyeye & Kenni, 2008]; and on the amino acid composition of the whole body, flesh and exoskeleton of the female crab [Adeyeye, 2008]. The present study is an attempt to assess the quality of the proximate and mineral composition, energy values as contributed by protein, fat and carbohydrate; and the mineral ratio parameters of the whole body (edible parts), flesh and exoskeleton of the female and male common West African fresh water *S africanus africanus*, bearing in mind that people prefer to consume certain parts and a certain sex of the crab. It is hoped that this work will further contribute information to food composition tables.

MATERIALS AND METHODS

Sudananautes africanus africanus samples were collected from the banks of River Osun, located at Ikere Ekiti, Ekiti State, Nigeria, during the rainy season (they normally hibernate in the dry season). Six pieces of matured fresh crabs (of each sex) were selected from more than 18 crabs caught in holes along the river banks meaning that 12 samples were used for this study. The crabs were caught at various times within two months along the long banks of the river and pulled together as composite samples for analysis. The samples were stored by freezing at –10°C.

Two whole crabs (of each sex) were separated fresh. While the internal organs were discarded, the other separated parts were dried in the oven at 105°C. For the purpose of analysis, the separated parts were the carapace and cheliped exoskeleton (to constitute the exoskeleton) and the muscle from the thoracic sterna and cheliped (to constitute flesh). The whole body constituted the cheliped (muscle and exoskeleton), carapace, thoracic sternum and the other four pairs of walking legs, and was then dried at 105°C. The whole body, exoskeleton and flesh samples were blended separately.

The micro-Kjeldahl method as described by Pearson [1976] was followed to determine the crude protein. The crude fat was extracted with a chloroform/methanol (2:1) mixture

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using Soxhlet extraction apparatus [AOAC, 2005]. Moisture, ash and crude fibre were also determined by the AOAC methods while carbohydrate was determined by difference. The calorific values in kilojoules (kJ) were calculated by multiplying the crude fat, protein and carbohydrate by Atwater factor of 37, 17 and 17 respectively. Determinations were made in duplicate.

The minerals were analysed from the solution obtained by first dry ashing the sample at 550°C. The filtered solutions were used to determine Na, K, Cu, Ca, Fe, Mn, Zn, Co, Mg, Ni and Cu by means of atomic absorption spectrophotometer (Buck Scientific Model – 200A/210, Norwalk, Connecticut 06855) and phosphorus was determined colorimetrically by Spectronic 20 (Gallenkamp, UK) using the phosphovanado molybdate method [AOAC, 2005]. All chemicals used were of British Drug House (BDH, London, UK) analytical grade. The detection limits for the metals in aqueous solution had been determined previously using the methods of Varian Techtron [1975] giving the following values in μg/mL: Fe (0.01), Cu (0.002), Na (0.002), K (0.005), Ca (0.04), Mg (0.002), Zn (0.005), Mn (0.01), Cr (0.005), Ni (0.02), and Co (0.05). The optimal analytical range was 0.1-0.5 absorbance units with coefficients of variation from 0.9% to 2.21%.

Calculations were made with the ANOVA and the comparison of calculated F values with those read from an F-table on d.f. = (1, n-2) at $p<0.05$ were further made to decide whether or not significant differences existed in the various parameters determined between the male and female samples of *S africanus africanus*. Other calculations were the energy values contributed by protein, fat and carbohydrate as well as utilizable energy due to protein. These ratios were also calculated for: [K/ (Ca + Mg)] (in milliequivalent) (meq), K/Na, Ca/P and Ca/Mg.

RESULTS AND DISCUSSION

Table 1 contains the proximate composition and energy value of male and female exoskeleton, flesh and the whole body. As indicated by the results, the protein level in male exoskeleton (ME) doubled the level in female exoskeleton (FE). Other values in ME greater than in FE were crude fat, moisture and the metabolizable energy. On the whole significant differences existed in the proximate levels of ME and FE at $p<0.05$. Our observations in ME and FE (Table 1) are very similar in most cases to the observations in flesh (MF and FF). The overall result was that the proximate parameters in MF were generally more concentrated than the FF. Significant differences also existed between MF and FF. In the whole body [M (WB) and F (WB)], protein, fat, ash and moisture in M (WB) were of higher values than in F (WB) and *vice versa* for the other parameters with significant differences occurring between M (WB) and F (WB) at $p<0.05$. Results compiled in Table 1 show also that the total ash in MF was higher than in ME and also that the total ash in FF was higher than in FE, meaning the flesh would likely contain higher levels of minerals than the exoskeleton of *S. africanus africanus.* The level of crude fat in male exoskeleton was higher than that in flesh and whole body. The metabolizable energy in MF was greater than in ME and was also greater in FF than in FE. The observation in the distribution of fat in the flesh and exoskeleton was similar to the observation in the shell and flesh of *Penaeus notabilis* but contrasted in total ash, crude protein and metabolizable energy [Adeyeye *et al.*, 2008].

Table 2 depicts the various energy values as contributed by protein, fat and carbohydrates. The energy levels in our samples (1.26–1.48 MJ) were comparable with the levels in turkey – hen muscle and skin (1.33–1.37 MJ) [Adeyeye & Ayejuyo, 2007] and cereals (1.3–1.6 MJ/100 g) [Paul *et al.*, 1978] but lower than the levels in sheep lean meat (2.06 MJ) and lean pork (2.29 MJ) [Fornias, 1996]; showing that crab exoskeleton and flesh are reasonable sources of energy. The daily energy requirement for an adult is between 2500–3000 kCal (10455–12548 kJ) depending on his physiological state while that of infants is 740 kCal (3095 kJ) [Bingham, 1978]. Taking into account the results in Table 2, it implies that while an adult man would require between 733–880 g (exoskeleton) to meet his requirement, infants would require 217 g (exoskeleton). This argument holds for other results in Table 2. The calculated values above are close to the results in turkey-hen muscle and skin [Adeyeye & Ayejuyo, 2007]. The energy requirements per day for some specific population are as follows: male office clerk (light activity work) is 10788 kJ/day and a subsistence farmer (moderate activity work) is 11662 kJ/

TABLE 1. Proximate composition (g/100 g) and energy (kJ/100 g) of the exoskeleton, flesh and whole body of male and female freshwater crabs (on dry weight basis).

Parameter	Exoskeleton*		Flesh*		Whole body*	
	Male	Female	Male	Female	Male	Female
	ME	FE	MF	FF	M (WB)	F (WB)
Crude protein	40.2	15.7	34.5	17.3	22.1	18.6
Crude fat	4.15	2.26	3.25	3.11	3.45	3.18
Total ash	4.60	6.24	7.36	10.1	14.9	7.04
Crude fibre	6.33	10.6	4.88	1.86	5.39	6.67
Moisture	10.5	7.65	9.41	8.54	9.54	8.77
Carbohydrate	34.7	57.5	45.4	59.1	44.6	55.7
Energy (kJ/100 g)	1426	1328	1480	1415	1262	1381

*Results were significantly different at $p<0.05$ for each paired group.

TABLE 2. Energy values as contributed by protein, fat and carbohydrate in the exoskeleton, flesh and whole body of male and female freshwater crabs (on dry weight basis).

Parameter	Exoskeleton		Flesh		Whole body	
	Male	Female	Male	Female	Male	Female
Total energy	1426	1328	1480	1415	1262	1381
PEP%	47.9	20.1	39.7	20.8	29.8	22.9
PEF%	10.8	6.29	8.13	8.13	10.1	8.51
PEC%	41.3	73.6	52.2	71.0	60.1	68.5
UEDP%	28.8	12.1	23.8	12.5	17.9	13.8

PEP = proportion of total energy due to protein; PEF = proportion of total energy due to fat; PEC = proportion of total energy due to carbohydrate; UEDP = utilizable energy due to protein.

day [FAO/WHO/UNU, 1985]. These values are much closer to the values of Bingham [1978]. The utilizable energy due to protein (UEDP%) for the crab (assuming 60% utilization) was 28.8% (male exoskeleton), 12.1% (female exoskeleton), *etc*., which are greater than the recommended safe level of 8% for an adult man who requires about 55 g protein per day with 60% utilization. This shows that the protein concentration in the crab samples in terms of energy would be more than enough to prevent energy malnutrition in children and adult fed solely on the crab as a main source of protein. The PEF% values were low (6.29–10.8) than the recommended level of 30% [NACNE, 1983] and 35% [COMA, 1984] for total fat intake, this is useful for people wishing to adopt the guidelines for a healthy diet.

Table 3 depicts the mineral composition of the *S africanus africanus* samples. In the Table, for the exoskeleton, elements Na, K, Ca, Mg and Mn were each more concentrated in the female exoskeleton than the male; in flesh samples, elements Na, K, Ca, Mg, Fe and Ni were more concentrated in the female flesh than in the male; in the whole body, elements Na, K, Ca, Mg, Zn, Fe, Co and P were more concentrated in the male whole body than the female whole body. This meant that the whole body results depicted the best observation for the relationship in the body distribution of minerals in *S africanus africanus*. Copper was not detected in any of the samples. However in *P notabilis,* all the detected minerals (Na, K, Ca, Mg, Zn, Cu, Fe, Mn and P) were all more concentrated in the exoskeleton than in the flesh [Adeyeye *et al.,* 2008]. Each pair of the samples was significantly different from each other at $p<0.05$.

The various mineral ratio parameters are shown in Table 4 for the *S africanus africanus* samples. In all the samples K/Na levels were greater than 1.0 except in female exoskeleton (FE) and whole body female [F (WB)]. Both Na and K are required to maintain osmotic balance of body fluid, they enhance the salt balance of the body fluid, the pH of the body, regulate muscle and nerve irritability, control glucose absorption and enhance normal retention of protein during growth [Adeyeye & Adamu, 2005]. The better ratio should be about 1.0. The Na/K ratio ranged from 0.86 to 1.35 which were higher than 0.60; the level that prevents high blood pressure [Nieman *et al*., 1992], therefore high K food will reduce the level of Na/K to the 0.60. The Ca/P ratios were low at 0.08 to 0.145. This might lead to low Ca absorption in the alimentary system. In fact the Ca/P is regarded as poor [Nieman *et al*., 1992]. The Ca/Mg ratios ranged from 0.81 to 1.25,

TABLE 3. Mineral composition (mg/100 g) of the exoskeleton, flesh and whole body of male and female freshwater crab (on dry weight basis)

Parameter	Exoskeleton*		Flesh*		Whole body*	
	Male	Female	Male	Female	Male	Female
	ME	FE	MF	FF	M (WB)	F (WB)
Na	17.7	24.0	29.6	34.3	26.0	20.7
K	17.9	19.2	34.5	36.5	30.0	15.3
Ca	21.3	24.0	24.4	30.9	33.0	27.9
Mg	22.0	23.2	30.1	30.0	28.3	22.2
Zn	5.26	5.10	8.14	7.90	10.1	7.79
Fe	8.35	5.64	11.4	15.0	9.76	7.12
Mn	0.45	0.54	1.15	0.87	0.44	0.76
Co	0.57	0.43	0.27	0.50	0.65	0.63
Ni	5.42	5.35	6.06	7.46	6.65	8.02
P	251	178	168	153	248	264
Cu	ND	ND	ND	ND	Nd	ND

ND = not detected. * Pairs were significantly different at $p<0.05$.

TABLE 4. Mineral ratio parameters of the exoskeleton, flesh and whole body of male and female freshwater crabs

Parameter	Exoskeleton		Flesh*		Whole body	
	ME	FE	MF	FF	M (WB)	F (WB)
K/Na	1.01	0.80	1.17	1.06	1.14	0.74
Na/K	0.99	1.25	0.86	0.94	0.88	1.35
Ca/P	0.08	0.13	0.145	0.20	0.13	0.11
Ca/Mg	0.97	1.03	0.81	1.03	1.16	1.25
[K/ (Ca+Mg)] [a]	0.83	0.81	1.26	1.20	0.96	0.61

a = milliequivalent; *Pair was significantly different at $p<0.05$.

which is close to the recommended value of 1.0. The [K/ (Ca + Mg)] obtained ranged from 0.61 to 1.26 milliequivalent (Table 4). To prevent hypomagnesemia, Marten & Andersen [1975] reported that the milliequivalent of [K/ (Ca + Mg)] must be less than 2.2 hence, the *S. africanus africanus* samples may not lead to hypomagnesemia.

CONCLUSIONS

In summary, *Sudananautes africanus africanus* exoskeleton, flesh and whole body would serve as good sources of protein, metabolizable energy, Ca, Mg, Zn, Fe, Mn, Ni and P, low fat source when it is consumed as meat source or as a complement/fortifier in lower quality protein foods. The maximum permissible levels of some heavy metals in food for human consumption on wet weight basis are: Hg (0.5 total μg/g); Cd (2.0 μg/g); Pb (2.0 μg/g); Cu (30.0 μg/g); Zn (1000 μg/g) [Wood, 1974]. Nigeria is not known to be polluted by Hg and Cd; there is contamination from Pb due to leaded petrol but not to deleterious level and Cu was not even detected in any of the samples; hence the crab samples are good for human consumption.

REFERENCES

1. Adeyeye E.I., Determination of chemical composition of the nutritionally valuable parts of male and female common West African fresh water crab *Sudananautes africanus africanus.* Int. J. Food Sci. Nutr., 2002, 53, 189–196.
2. Adeyeye E.I., Amino acid composition of the whole body, flesh and exoskeleton of female common West African fresh water crab *Sudananautes africanus africanus*. Int. J. Food Sci. Nutr., 2008, 59, 699–705.
3. Adeyeye E.I., Adamu A.S., Chemical composition and food properties of *Gymnarchus niloticus* (Trunk fish). Biosci. Biotech. Res. Asia, 2005, 3, 265–272.
4. Adeyeye E.I., Ayejuyo O.O., Proximate, amino acid and mineral composition of turkey-hen muscle and skin. Orient. J. Chem., 2007, 23, 879–886.
5. Adeyeye E.I., Kenni A., The relationship in the amino acid of the whole body, flesh and exoskeleton of common West African fresh water male crab *Sudananautes africanus africanus*. Pak. J. Nutr., 2008, 7, 748–752.
6. Adeyeye E.I., Adubiaro H.O., Awodola O.J., Comparability of chemical composition and functional properties of shell and flesh of *Penaeus notabilis*. Pak. J Nutr., 2008, 7, 741–747.
7. A.O.A.C., Official Methods of Analysis, 18th ed., 2005. AOAC International, Maryland, USA.
8. Bingham S., Nutrition: A consumer's Guide to Good Eating. 1978, Transworld Publishers, London, pp. 123–127.
9. Bulloug W.S., Practical Invertebrate Anatomy. 1958, Macmillan Press, London.
10. Committee on Medical Aspects (COMA) of Food Policy, Diet and Cardiovascular Disease, 1984. HMSO, London.
11. FAO/WHO/UNU. Energy and protein requirements, 1985. Report of a Joint FAO/WHO/UNU Expert Consultation on Energy and Protein Requirements. WHO Technical Report Series 724, WHO, Geneva, pp. 71–78.
12. Fornias O.V., Edible by-products of slaughter animals. 1996. FAO Animal Production and Health Paper 123, FAO, Rome, p. 9.
13. Marten G.C., Andersen R.N., Forage, nutritive value and palatability of 12 common annual weeds. Crop Sci., 1975, 111, 829––837.
14. Muller H.G., Tobin G., Nutrition and Food Processing. 1980, Avi Publishing, Westport, CT, p. 195.
15. National Advisory Committee on Nutrition Education (NACNE), Proposal for nutritional guidelines for healthy education in Britain. 1983, Health Education Council, London.
16. Nieman D.C., Butterworth D.E., Nieman C.N., Nutrition. 1992, Wm C. Brown Publishers, Dubuque, pp. 1–540.
17. Paul A.A., Southgate D.A.T., McCance and Widdowsor's The Composition of Foods, 4th edition, 1978. HMSO, London.
18. Pearson D., Chemical Analysis of Foods. 1976, 7th ed., Churchill, London, pp. 7–11.
19. Varian Techtron, Basic Atomic Absorption Spectroscopy: A modern introduction, 1975. Varian Techtron Pty Ltd., Springvale, Australia, pp. 104–106.
20. Wood J.M., Biological cycles for toxic elements in the environment. Science, 1974, 183, 1049–1052.

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