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CHEMICAL COMPOSITION OF FEMALE AND MALE GIANT AFRICAN CRICKETS, *BRACHYTRYPES MEMBRANACEUS* L

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ABSTRACT

Female and male dry samples of giant African crickets, *Brachytrypes membranaceus* L were analysed. The comparison of female and male results showed that significant differences ($p<0.05$) existed in the correlation coefficients in the proximate composition (r_{xy} = 0.89), mineral composition (r_{xy} = 0.79), amino acids composition ((r_{xy} = 0.81), and amino acid scores (r_{xy} = 0.84); with corresponding regression coefficients (R_c) of: proximate (0.74), minerals (0.62), amino acids (0.50) and amino acid scores (0.51). The above showed that the composition values in the female samples were higher than in the male samples in the various parameters determined.

KEY WORDS

Giant African crickets, female and male, composition values.

INTRODUCTION

The cricket is a very large, brown insect which lives under – ground in the soil. It has wings and can fly. In the night it makes a loud, sharp noise. This noise is made when the two wings are rubbed together against each other. Crickets feed on the roots of plants in the soil [1].

One kind of cricket is the bush cricket. It is closely related to the grasshopper. It is large and green. Bush crickets can be found resting on plants in the bush. They feed on the leaves of plants and lay their eggs either in the soil or on the stems of soft plants like cocoyam. They too can make a noise by rubbing their back legs against their wings [1]The brown cricket, giant African cricket, *Brachytrypes membranaceus* L. lives in a hole in the field. The hole is usually covered with a small heap of soil (particularly the female) which the cricket dug from the earth to make its home. In West Africa, some children dig the brown crickets from their holes, roast and eat them. Crickets come out of their holes at night when they can be picked life.

Conventional animal protein is in limited supply in Nigeria and relatively expensive, and efforts are being made to identify more sources. This work aims to draw attention to the nutritional value of *B. membranaceus,* particularly its proximate, mineral and amino acid composition. Such information will enhance food composition tables and might lead to nutrient applications of *B. membranaceus.* Earlier the proximate and mineral composition of the wings, eggs and food properties of crickets (*B. membranaceus)* had been reported [2].

MATERIALS AND METHODS

B. membranaceus were collected between the months of September and October. They were collected at night (particularly the females) when they came out of their holes or the identified holes were dug to fish them out. They were put in dry containers with tight cover and brought to the laboratory. The insects were oven-dried at 80-85 ^{o}C, cooled, and the non-edible parts removed. The edible portion (200 g) was dry-milled into flour and kept in deep freezer in McCartney bottles pending analysis.

Moisture, ash, crude fibre and ether extract were determined by AOAC [3] methods. Nitrogen was determined by the micro-Kjeldahl method [4] and the crude protein was taken as N% x 6.25. Carbohydrate was determined by difference. The metabolisable energy was calculated as (protein x 17) + (fat x 37) + (carbohydrate x 17) kJ/g [5]. All the energy levels were reported in kJ/kg.

Minerals were analysed using the solution obtained by dry ashing the sample at 550 ^{o}C and dissolving it in 10 % HCl (25 ml) and 5 % lanthanum chloride (2 ml), boiling, filtering and making up to standard volume with distilled deionized water. Mg, Ca, Zn, Mo, Mn, Cu, Se, Ni and Fe were determined with a Buck Atomic Absorption Spectophotometer (Buck Scientific Inc, Norwalk, CT, USA). Na and K were measured with a flame photometer (Corning, Halstead Essex, UK, Model 405)[5]. The detection limits had previously been determined using the methods of Varian Techtron [6] all for aqueous solutions. The optimum analytical range was 0.5–1.0 absorbance units with a coefficient of variation of 0.05-0.40 %. Phosphorus was determined using a Spectronic 20 colorimeter (Gallenkamp, London, UK) by the phosphovanado–molybdate method [3]. All chemicals used were BDH analytical grade obtained from British Drug House (BDH, London, UK).

About 2.0 g of each sample was weighed into the extract thimble and the fat extracted with chloroform/methanol (2:1) mixture using extraction apparatus [3]. The extraction lasted for 5-6 h. Between 30–35 mg of the defatted samples were weighed into the glass ampoule. 7 ml of 6 M HCl was added and oxygen was expelled with nitrogen. The glass ampoule was then sealed with Bunsen flame and put in an oven preset at 105 ^{o}C±5 ^{o}C for 22 h. The ampoule was allowed to cool before breaking open at the tip and the content was filtered to remove the humins. The filterate was then evaporated to dryness at 40 ^{o}C under vacuum in a rotary evaporator. The residue was dissolved with 5 ml of acetate buffer (pH 2.0) and stored in plastic specimen bottles which were kept in the deep freezer. The method of amino acid analysis was by ion–exchange chromatography (IEC) [7]. The Technicon Sequential Multisample Amino acid Analyzer (TSM) (Technicon Instruments Corporation, New York, USA) was used for the analysis. The period of an analysis lasted for 76 minutes for each sample. The gas flow rate was 0.50 ml/min at 60 ^{o}C with reproducibility within ± 3 %. The net height of each peak produced by the chart record of the TSM was measured and calculated. All the amino acid values were reported on mg/g crude protein on dry weight basis.

The estimation of the isoelectric point (pI) for a mixture of amino acids can be carried out by the equation of the form:

$$IPm = \sum_{i-1}^{n} IPiXi$$

where IPn is the isoelectric point of the mixture of amino acids, IPi is the isoelectric point of the i^{th} amino acid in the mixture and Xi is the mass or mole fraction of the i^{th} amino acid in the mixture [8].

The quality of dietary protein can be measured in various ways [7] but basically it is the ratio of available amino acids in the food or diet compared with needs expressed as a ratio

[9,10]. The following formula was used to calculate the scores:

$$\text{Amino acid score} = \frac{\text{mg of amino acid per g of test protein}}{\text{mg of amino acid per g protein in reference protein}}$$

All our results were subjected to statistical analysis. Mean (X), standard deviation (SD) and coefficients of variation percent (CV %) were calculated [11]. Also calculated were the correlation coefficients (r_{xy}), coefficient of alienation (C_A), index of forecasting efficiency (IFE) and regression coefficient (R_c). The r_{xy} was converted to table value to see if significant differences existed among the sample results at $p < 0.05$ [12]. Also calculated were the F test values at $p < 0.05$ for essential versus non – essential amino acids, essential versus essential amino acids per sample and amino acid scores for each sample.

RESULTS AND DISCUSSION

The proximate compositions of *B. membranaceus* is in Table 1. The crude protein and the carbohydrate were high with 324 (male) – 258 g/kg (female) and 489 (male) – 548 g/kg (female) respectively. The fat and fibre were low with 32 (male) – 53 g/kg (female) and 85 (male) – 80 g/kg (female) respectively. The protein and fat contents of locusts are 490-610 and 100-180 g/kg respectively, and for termites 450 and 352 g/kg respectively [13]. The protein and fat contents are 549 and 133 g/kg respectively in *Zonocerus variegatus* [14]. The ash contents, 66 (male) – 49 g/kg (female) were higher than the value of 31 g/kg in *Z. variegatus*. The energy contents ranged from 15 (male)–16 MJ (female) which compared favourably with the cereal value of 13–16 MJ/kg [5] indicating that *B. membranaceus* could be a concentrated source of energy. The r_{xy} value between female and male samples was 0.89 which was significant at $p < 0.05$. For every

Table 1

Proximate and mineral composition of B membranaceus on dry weight basis

Parameter		Concentration Female (x)	Male (y)	$\bar{X}^a \pm SD^b$	CV%[c]	r_{xy}	R_c	C_A	IFE
Total ash	g/kg	49	66	57±1.2	21.0				
Moisture	g/kg	12	5.0	9.0±0.5	57.5				
Crude protein	g/kg	258	324	291±4.6	15.8				
Fibre	g/kg	80	85	82±0.3	3.7	0.89*	0.74	0.46	54.4
Crude fat	g/kg	53	32	42±1.5	35.6				
Carbohydrate	g/kg	548	489	519±4.2	8.1				
Energy	kJ/kg	15663	15005	15334±46.5	3.0				
Magnesium	mg/kg	215	213	214±1.4	14.1				
Calcium	mg/kg	86	124	105±2.7	25.7				
Zinc	mg/kg	515	1032	774±36.6	47.3				
Molybdenum	mg/kg	ND[d]	ND	-	-				
Manganese	mg/kg	15	21	18±4.4	24.2				
Copper	mg/kg	ND	ND	-	-	0.79*	0.62	0.61	39
Potassium	mg/kg	746	1122	1019±38.6	37.9				
Selenium	mg/kg	ND	ND	-	-				
Sodium	mg/kg	1037	2226	1631±84.1	51.5				
Nickel	mg/kg	ND	ND	-	-				
Iron	mg/kg	100	31	55±4.9	75.1				
Phosphorus	mg/kg	10880	10936	10908±39.2	0.4				

[a]$\bar{X}$ = mean; [b]SD = standard deviation; [c]CV% = coefficient of variation percent;
*[d]ND = not detected; [e]- = not determined, r_{xy} = correlation; R_c = regression coefficient; C_A = coefficient of alienation; IFE = index of recasting efficiency per cent; * = significant difference at $p < 0.05$.*

one unit rise in the female proximate value it was 0.74 in the male. The reduction in the error of prediction of relationship between female and male proximate values was 54.4 % as indicated by index of forecasting efficiency (IFE) percent.

The mineral composition is also in Table 1. The iron content (31–100 mg/kg) was less or greater than the value of 37 mg/kg in *Z. variegatus* and less or greater than the values in various African edible snails (46–93 mg/kg) [15] but greater than those reported for some freshwater fish (2-5 mg/kg) [16, 17]. The zinc content was better than in the three snails and the fishes cited above. Copper, selenium, molybdenum and nickel were not detected. *B. membranaceus* was a good source of zinc, potassium, sodium and phosphorus. The sodium and potassium contents were far greater than the values of 366 mg/kg and 450 mg/kg respectively in *Z. variegatus;* 125–631 mg/kg and 125–169 mg/kg respectively in Nigerian freshwater fish [17]. The sodium and potassium values here were also better than the values in *Illisha africana* fish which contained 62–148 and 64–87 mg/kg of Na and K respectively [18]. The calcium contents (124-86 mg/kg) were higher than that in the *Z. variegatus* (70 mg/kg) but lower than the values in snails (222–2120 mg/kg) [15] and *I. africana* fish (138–181 mg/kg) [18]. The phosphorus values of 10936-10880 mg/kg was much higher than the value of 600 mg/kg in *Z. variegatus* and the manganese value of 21–15 mg/kg was also better than 3 mg/kg reported for *Z. variegatus* [14]. All the minerals reported here: Mg, Ca, Zn, Mn, K, Na, Fe and P have values which were all lower than the corresponding values obtained for male and female freshwater crabs [19]. The r_{xy} value was 0.79 with regression value of 0.62 meaning that the corresponding values in female were generally better than in the male. However, the reduction in error of prediction was lower (38.7 %) than in the proximate composition. Ca/P ratio was 0.01 and Na/K ratio was 2.0 – 1.4. These values were poor. For good calcium absorption the Ca/P ratio should have between 0.5 > 1.0 while prevention of high blood pressure should have Na/K of 0.60. Therefore foods of excellent Ca/P ratios and foods higher in potassium than sodium should be eaten with cricket to maintain critical health conditions [20].

The amino acids compositions of cricket samples are shown in Table 2. The amino acid concentrations were variously concentrated among the various samples as shown in the coefficients of variation percent (CV %). Glu was highest in both samples with 118.9 mg/g crude protein (male) and 184.4 mg/g crude protein (female) with a CV % of 30.5. While Cys had the lowest value (13.8 mg/g crude protein) in the male, it was Pro (16.6 mg/g crude protein) in the female. The present results agreed with the results in oil seeds where Asp and Glu were the major amino acids [21]. The present essential amino acid values were favourably comparable to the published results in milk and beef [9] and egg [22]. The r_{xy} was 0.81 which was significantly different; the regression coefficient was

Table 2

Amino acid composition of B. membranaceus (mg/g crude protein) dry weight basis

Amino acid IFE	Concentration Female (x)	Male (y)	$\bar{X}$±SD	CV%	r_{xy}	R_c	C_A	
Lysine (Lys)[a]	44.0	34.1	39.1±7.0	17.9				
Histidine (His)[a]	22.9	20.6	21.8±1.6	7.3				
Arginine (Arg)	41.8	35.2	38.5±4.7	12.2				
Aspartic acid (Asp)	88.8	58.1	73.5±21.7	29.5				
Threonine (Thr)	17.9	17.5	17.7±0.3	1.7				
Serine (Ser)	39.9	31.3	35.6±6.1	15.3				
Glutamic acid (Glu)	184.4	118.9	151.7±46.3	30.5				
Proline (Pro)	16.6	20.6	18.6±2.8	15.1				
Glycine (Gly)	51.7	41.0	46.4±7.6	16.4	0.81*	0.50	0.59	41
Alanine (Ala)	44.5	28.7	36.6±11.2	30.6				
Cystine (Cys)	18.1	13.8	16.0±3.0	18.8				
Valine (Val)[a]	35.1	41.3	38.2±4.4	11.5				
Methionine (Met)[a]	26.3	16.0	21.2±7.3	34.4				
Isoleucine (Ile)[a]	53.2	38.8	46.0±10.2	22.2				
Leucine (Leu)[a]	60.0	50.2	55.1±6.9	12.5				
Tyrosine (Tyr)	27.3	23.3	25.3±2.8	11.1				
Phenylalanine (Phe)	38.5	34.8	36.7±2.6	7.1				

[a]Essential amino acids

0.50 with a coefficient of alienation of 0.59 and a reduction of the error of prediction of 41 %. These results showed that the female amino acid values were correspondingly higher than the values in males.

Many parameters were depicted in Table 3. The total amino acid (TAA) ranged between 624.2 (male) – 811 mg/g (female) with CV %) of 18.4. These values were lower than the values in dehulled African yam bean (AYB) (702.9–917.5 mg/g crude protein) [23]. The total non-essential amino acid (TNEAA) of 335.7 (male) – 471.3 mg/g (female) were favourably comparable to those of AYB of 327.2–453.8 mg/g protein. The total essential amino acid (TEAA) was high in all the samples, the values ranged from 288.5–339.7 mg/g protein (with histidine) and 267.9-316.8 mg/g protein (without histidine).

Table 3

Essential, non-essential, neutral, acidic and basic amino acids (mg/g crude protein) of B.membranaceus

Amino acid	Concentration Female	Concentration Male	$\bar{X}$±SD	CV%
Total amino acid (TAA)	811.0	624.2	717.6±132.1	18.4
Total non-essential amino acid (TNEAA)	471.3	335.7	403.5±95.9	23.8
Total essential amino acid (TEAA) -with histidine	339.7	288.5	314.1±36.2	11.5
- no histidine	316.8	267.9	292.4±34.6	11.8
Percent total non – essential amino acid (% TNEAA)	58.1	53.8	56.0±3.0	5.4
Percent total essential amino acid (% TEAA) - with histidine	41.9	46.2	44.1±3.0	6.8
- no histidine	39.1	42.9	41.0±2.7	6.6
Total neutral amino acid (TNAA)	429.1	357.3	393.2±50.8	12.9
% TNAA	52.9	57.2	55.1±3.0	5.4
Total acidic amino acid (TAAA)	273.2	177.0	225.1±68.0	30.2
% TAAA	33.7	28.4	31.1±3.7	11.9
Total basic amino acid (TBAA)	108.7	89.9	99.3±13.3	13.4
% TBAA	13.4	14.4	13.9±0.7	5.0
Isoelectric point (pI)	4.4	3.5	3.95±0.64	16.2

Tryptophan (Try) was not determined in the samples. These results were favourably comparable to the TEAA values in cow's milk, 490 (with histidine but without Try) and 463 (no histidine, no Try); beef, 467 (with histidine but no Try) and 433 (no His, no Try); and egg, 495 (with His but no Try) and 473 (no His, no Try) [22]. Percent TNEAA ranged between 53.8–58.1 while the percent TEAA ranged between 46.2–41.9 (with His) and 42.9–39.1 (without His) showing that the samples were better concentrated in TNEAA; also the male sample was better concentrated in TEAA than the female sample in the overall percentage. The TEAA in the values were slightly less than the value of 444 mg/g in soya bean [24]. The percentages of total neutral amino acid (TNAA) ranged from 57.2–52.9 indicating that it formed the bulk of the amino acids; total acidic amino acid (TAAA) present ranged from 28.4–33.7 which was lower than % TNAA while the percent range in total basic amino acid (TBAA) was 14.4 – 13.4 which made it the least largest group among the samples.

Using data from Table 2 together with the scoring pattern from Table 4, the values of the essential amino acid scores (EAAS) were calculated. Results of the amino acid scores are shown in Table 4. Table 2 showed a wide range of variation in the EAA of the cricket samples and this agreed with Salunkhe *et al.*[25]. The amino acid scores in the cricket samples also showed this type of variation (Table 4). The variations here were lower than the values reported for the hulled seeds of AYB [26]. Table 4 showed that Phe + Tyr had the least CV % of 9.6, Met + Cys had a variation of 28.3 %, Ile had CV % of 26.1 while CV % for Val was 11.1 but CV % was not calculated for Thr because the SD was zero. The limiting amino acid was Thr for the two cricket samples with values that ranged between 0.44 and 0.45. Thr was also found to be limiting in four samples of dehulled AYB [23]. Some of the amino acid scores were greater than 1.0 showing the high quality of the cricket proteins. Both His and Arg are particularly essential for children [22, 27, 28] and these results in the samples (Table 2) showed them to be good sources of the amino acids. The r_{xy} was 0.84 while Rc was 0.51; also C_A was 0.54 while IFE was 46 %. The essential amino acids most often acting in a limiting capacity are methionine (and cystine), lysine and tryptophan [29]. Lysine score was 62 % in male and 80 % in female crickets. This meant, to avoid any EAA wastage, 100/62 or 1.61 times protein from the male and 100/80 or 1.25 times protein from the female samples would be required to balance the deficiencies.

The isoelectric points were calculated from a table of amino acid isoelectric points [30]. The neutral amino acids (NAA) from the samples were Gly, Ala, Val, Ile, Leu, Tyr, Phe, Ser, Cys, Thr, Met and Pro. These amino acids do not give isoelectric point values at neutral points but near to it, that is, 5.0 to 6.3. The results have acidic amino acids (AAA) Asp and Glu with isoelectric points 3.0 and 3.1 respectively while the basic amino acid (BAA) values were Arg, Lys and His whose isoelectric point values ranged from 7.6

Table 4.

Provisional amino acid scoring pattern[a] and amino acid scores for B. membranaceus

Table 4.
Provisional amino acid scoring pattern[a] and amino acid scores for B. membranaceus

Amino acid	Suggested Level		Sample score			CV%	r_{xy}	R_c	C_A	IFE
	mg/g of protein[b]	mg/g of nitrogen	Female(x)	Male(y)	$\overline{X}$±SD					
Ile	40	250	1.33	0.97	1.15±0.3	26.1				
Leu	70	440	0.86	0.72	0.79±0.1	12.7				
Lys	55	340	0.80	0.62	0.71±0.1	14.1				
Met + Cys[c]	35	220	1.27	0.85	1.06±0.3	28.3	0.84*	0.51	0.54	
46 Phe + Tyr	60	380	0.45	0.97	1.04±0.1	9.6				
Thr[d]	40	250	1.10	0.44	0.45±0.0	-[e]				
Val	50	310	0.92	0.83	0.9±0.1	11.1				
Try[f]	10	60	-	-	-	-				
Total	360	2250	0.92	0.77	0.85±0.1	12.5				

[a]Source: Bingham (1977);
[b]Values used in scoring in the current report;
[c]TSAA = Total sulphur amino acids;
[d]Limiting amino acid; -[e] = not determined;
[f]Not used in calculating sample scores

to 10.8. Based on these observations it was decided to calculate theoretically the isoelectric points (pI) of the samples and the following results were obtained: 3.5 (male) and 4.4 (female) with a CV % of 16.2 showing the values to be close. The result of the functional properties of *B. membranaceus* actually gave values of pI 3.0 (male) and 4.0 (female) [2]. Olaofe and Akintayo [8] have used theoretical calculations to predict the isoelectric points of legume and oilseed proteins from their amino acid composition. Their results suggested that the predicted values fairly agreed with the experimentally determined values. In the present report, the percentage differences between the calculated pI and experimental results were 14.3 (male) and 9.1 (female). It is therefore a good starting point in predicting isoelectric points for proteins in order to enhance a quick precipitation of protein isolate from biological samples.

While it is known that cystine can spare part of the requirement for methionine, FAO/WHO/UNU [22] does not give any indication of the proportion of total sulphur amino acids which can be met by cystine. For the rat, chick and pig, the proportion is about 50 % [7]. Most animal proteins are low in cystine; in contrast, many vegetable proteins, especially the legumes, contain substantially more cystine than methionine. Thus, for animal protein diets or mixed diets containing animal protein, cystine is unlikely to contribute more than 50 % of the total sulphur amino acids [7]. This point is amplified by our results with the following values: female cricket (40.8 %) and male cricket (46.3 %) respectively. Similar observations were made in land snails consumed in Nigeria: *Archachatina marginata* (35.3 %), *Archatina archatina* (38.8 %) and *Limicolaria* sp. (21.0 %) respectively [31]; 25.6 % in *Zonocerus variegatus* [32]; 36.6 % in *Macrotermes bellicosus* [33]; 27.3 in whole body, 30.4 in flesh and 32.8 in exoskeleton of West African fresh water crab [34]. Such results in vegetables were 62.8 % in coconut endosperm [35]; it ranged between 58.9–72.0 % in guinea corn grains [36].

The data obtained for the TNEAA, TEAA and essential amino acid scores (EAAS) were subjected to F test as follows: TEAA/TNEAA, TEAA/TEAA and EAAS/EAAS. The following results were obtained: in cricket male sample, TEAA/TNEAA value was F_c (8.57) > F_t (3.50) at $p < 0.05$, result significant, but in both TEAA/TEAA and EAAS/EAAS $F_c < F_t$, results not significant; in female, TEAA/TNEAA value was F_c (16.07) > F_t (3.50) at $p < 0.05$, result significant, but in both TEAA/TEAA and EAAS/EAAS $F_c < F_t$, results not significant at $p < 0.05$.

CONCLUSION

Brachytrypes membranaceus was a good source of protein, carbohydrate and energy and of major and trace minerals. The World Health Organisation recommended Val and Ile requirements for school children aged 10-12 years of 33 and 30 mg amino acid/kg body weight/day [22, 37]. For example a 30 kg child will require 990 and 900 mg of Val and Ile per day respectively. Male cricket contained 324 g/kg protein and female cricket contained 258 g/kg protein, 100 g *B. membranaceus* would provide approximately 1338.12 and 1257.12 mg of Val and Ile amino acids by the male sample while the female would provide 905.58 and 1372.56 mg of Val and Ile amino acids. If a 30 kg child therefore consumes 100 g of *B. membranaceus* per day, his WHO daily requirements of Val and Ile, will be met. The same conclusion can be drawn for almost all the amino acids. One can also conclude that the giant African cricket amino acids that will meet the requirements of a child will also meet that of an adult [23, 37].

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