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Evaluation of Nutritive Properties of the Large African Cricket (*Gryllidae* sp)

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Abstract. The large African cricket (*Gryllidae* sp) was subjected to standard analytical procedures to determine its proximate composition, functional properties, amino acids spectrum, *in vitro* protein digestibility, and nutritionally valuable minerals. The moisture was low (2.13-3.48%), while the protein content was high (65.95%) in the male cricket and 65.11% in the female cricket). Seventeen amino acids were detected. The essential amino acids contributed 46.1-47.8% of the total amino acid content. Results of the *in vitro* protein multienzyme digestibility indicated high digestibility (90.7-94.7%). The amino acids scores were also favourable. The crude fibre and fat contents were fairly high, while the total carbohydrates were low (8.26-12.49%). The carbohydrates fraction contained 85.9-88.0% carbohydrates as stored glycogen. Phosphorus was the highest mineral in the ash (180.92 mg per 100 g), while the concentration of zinc was the lowest (1.46 mg per 100 g). Copper, manganese, nickel and lead were below the detection limits. Observations on the functional properties revealed low gelation, oil absorption, and emulsion capacity and stability. The effect of pH on the protein solubility showed that the lowest solubility occurred at the pH value of 4.0, while maximum solubility was recorded at the pH values of 6 and 7.

Keywords: *Gryllidae* sp, nutritional properties, functional properties, large African cricket, new protein source, *Gryllidae* amino acids

Interoduction

The large African cricket (*Gryllidae* sp) is one of the most notorious and highly destructive pest of many economic crops in the Western, Central and Eastern parts of Africa (Daramola, 1974). Several authors have observed that this pest attacks animals, herbs and plantation crops at their nursery stages (Hewuirlt, 1980; Daramola, 1974; Kaufmann, 1965; Chapman, 1962). This field cricket has been reported to feed on a wide variety of food plants, such as banana, and tea and coffee seedlings (Toye, 1982), and some commercial crops, including *Amaranthus* sp, *Rosa* sp, *Mangifera indica, Theobroma cacao* and *Cola* sp. The female insects, which have an elongated banana-shaped abdomen, lay eggs in batches, approx 2000 eggs in a batch. At room temperature (30±2 °C), the eggs hatch in 10-12 days. The development of the nymphs takes 40-60 days. The adults, which generally live for 2 to 3 months, are omnivorous. The crickets grow up to 2-3 inches in length. The females have long ovipositor, about 18 mm in length.

In view of the nutritive properties of similar insects, a study on the chemical composition of the large African cricket was given consideration. These studies aimed at solving two problems. Firslty, to reduce the destructive effects of this insect in terms of reduction in their population size to alleviate the problem. Secondly, to overcome the problem of shortage of high quality protein sources and the prevalence of protein malnutrition in the developing countries. It was against this background, that the nutritional properties of the adult male and female large African cricket (*Gryllidae* sp) was investigated.

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Materials and Methods

Materials. The adult male and female crickets (*Gryllidae* sp) were collected during the wet season (April to August), when their population is at the peak. They were collected from Ibadan, Ile-Ife, Ilesa, Akure, Iseyin, Tede and the entire South-western Nigeria. The insects were demobilised by asphyxiating them in deep freezers at - 20 °C. Their alimentary canals were carefully removed and the samples subsequently dried to constant weight in an oven at 40 °C. The dried samples were pulverised into fine powder using a Christy laboratory mill. The samples were stored in dry air-tight plastic containers at 4 °C.

Analytical methods. Proximate analysis of the samples for moisture, crude fibre, protein and ash contents was carried out according to AOAC (1990). Carbohydrate fractions were

analysed using the method described by Esuoso and Odetokun (1995). Mineral elements were determined by pre-ashing 2 g of the samples in a silica crucible and heating on a gas flame for 10 min. The samples were transferred to a muffle furnace and incinerated at 900 °C for 6 h. The residual white ash was dissolved in 0.1 M HNO_3. The metals were determined by atomic absorption spectrophotometer (Perkin-Elmer 8650). Phosphorus was estimated by using the vanado-molybdate method (Vogel, 1978).

The method of Coffman and Garcia (1977), with slight modification, was employed for the determination of gelation capacity. Sample suspensions were prepared in distilled water. Ten ml of each suspension was poured into a test tube and slowly heated for 1 h in a boiling waterbath, followed by rapid cooling in a waterbath of cold water for 10 min. All the tubes were further cooled in a waterbath at 4 °C for 2 h. The least gelation concentration was determined as that concentration when the sample from the inverted tube did not fall down or slip. Water and oil absorption capacities were determined by the method of Sathe and Salunkhe (1981). The foaming capacity for each sample suspension was determined by the method described by Narayana and Narsinga (1982), while the emulsion capacity and stability was determined by the method of Yasumatsu *et al.* (1972). All determinations were carried out in triplicate.

For amino acids determination, the samples were hydrolysed with 6 N HCl for 3 h at 150 °C *in vacuo*.The amino acids solution was derivatised with an amino acid derivatiser/analyser model 420A using phenylisocyanate in the presence of diisopropylethylamine. The derivative was analysed with a reverse phase high performance liquid chromatography (RP-HPLC) microseparation system model 130A, consisting of pump type P680, ASI-100T automated sample injector and PDA-100 photodiode array detector.

The *in vitro* multienzyme digestibility was carried out by the method of Hsu *et al.* (1977). Fifty ml of aqueous suspension of the samples (6.25 mg sample per ml) in distilled water was adjusted to pH 8.0 with 0.1 M HCl and/or 0.1 M NaOH, while stirring on a waterbath maintained at 37 °C. The multienzyme solution containing 1.6 mg trypsin, 3.1 mg chymotrypsin and 1.3 mg peptidase was maintained in an ice-bath and adjusted to pH 8.0 with 0.1 M HCl and/or 0.1 M NaOH. The enzymes were purchased from Sigma Chemical Company (St. Louis, MO, USA). A 5 ml sample of the multienzyme solution was added to the sample suspension with constant stirring at 37±2 °C. The pH of the suspension was recorded for 15 min after the addition of the multienzyme solution. The *in vitro* digestibility was calculated by using the regression equation of Hsu *et al.* (1977). The enzyme activity was determined by using casein of known *in vivo* apparent digestibility.

Results and Discussion

The proximate chemical composition of the large African cricket is shown in Table 1. The moisture content of the crickets was low (2.13-3.48%). The low value may be regarded as advantageous in terms of the shelflife of the insects. The crude protein content was very high (65.95% in the male crickets and 65.11% in the female crickets). The values were higher than that reported for other insects and animal sources. Termites were reported to contain 37.39%, while the female reproductive termites contained 56.24% crude protein (Ajakaiye and Bawo, 1990). Similar results have been obtained in similar insects (Udoh *et al.,* 1985; Mba, 1980). Therefore, based on the average human protein intake of 23-50 g, as recommended by the National Research Council (1974), the large African cricket may contribute significantly in alleviating the problem of protein malnutrition in the Third World and developing countries.

The amino acids composition of the male and female crickets is shown in Table 2. The contant of essential amino acids was high in samples of both the sexes (448.6 and 491.9 mg/g in the male and female crickets, respectively). Aspartic acid and glutamic acid occurred in the highest concentration in the two categaries of samples. The nutritive value of proteins depends primarily on their capacity to satisfy the needs of nitrogen and essential amino acids (Pellet and Young, 1980). The aliphatic amino acids (isoleucine, leucine, valine), which constitute the hydrophobic regions of the protein were fairly high in both the sexes of the cricket samples. This implies better emulsifying properties of these samples. In addition, the essential amino acid (phenylalanine) and tyrosine were high in the two types of samples. These amino acids are precursors for the synthesis of tyrosine, epinephrin and thyroxin, which are important constituents of the body's endocrine system (Robinson, 1987). A comparison of the amino acids composi-

Table 1. Proximate chemical composition (g/100 g) of male and female crickets (*Gryllidae* sp)

Composition*	Male	Female
Moisture	2.13 ± 0.05	3.48 ± 0.02
Crude protein (N x 6.25)	65.95 ±0.14	65.11 ±0.07
Crude fat	7.25 ±0.03	10.78 ±0.05
Ash	5.68 ±0.07	4.31 ± 0.04
Crude fibre	6.51 ±0.12	8.06 ± 0.10
Carbohydrates**	12.49 ±0.08	8.26 ± 0.06

*values are given as mean ± sd of triplicate determinations (dry wt basis); **carbohydrates expressed as glycogen

Table 2. Amino acids composition and *in vitro* digestibility of the male and female crickets (*Gryllidae* sp)

Amino acid	Composition (mg/g crude protein)	
	Male	Female
Aspartic acid	120.5	115.8
Glutamic acid	110.7	100.6
Serine	90.7	81.5
Glycine	`42.3	55.8
Histidine	37.6	46.2
Arginine[a]	48.9	51.6
Alanine	50.6	58.4
Tyrosine	37.3	57.6
Valine[a]	70.9	84.7
Methionine[a]	20.1	59.6
Cystine	22.0	10.5
Isoleucine[a]	55.8	50.9
Leucine[a]	79.6	71.5
Phenylalanine[a]	51.6	58.5
Threonine[a]	49.6	41.7
Lysine[a]	70.1	73.4
Tryptophan	10.5	11.7
Total essential amino acids (TEAA)	446.6	491.9
Total non-essential amino acids (TNEAA)	522.2	538.1
TNEAA (% of total amino acids)	53.9	52.2
TEAA (% of total amino acids)	46.1	47.8
In vitro enzyme digestibility(%)*	90.7±1.4	94.7±1.4

[a]essential amino acids; *digestibility of casein as reference protein (standard protein) = 94.3%

tion in both the cricket samples with the FAO/WHO reference values (FAO/WHO, 1985), indicated that the values obtained during this study were higher than the values recommended for pre-school and school going children. This implies that the cricket samples are a good source for essential amino acids and may be used for the fortification of cereal-based foods, which are particularly deficient in lysine. The quality of dietary proteins can be measured in many ways. There is a general acceptance that this value is a ratio of the available amino acids in the food or diet, as compared with the daily requirements. According to the provisional amino acids scoring pattern and amino acids score reported in Table 3, the amino acids score compared favourably with the suggested reference standards. Perhaps the limiting amino acids would be leucine and threonine in the female cricket samples. Otherwise, the amino acids score was adequate in both the male and female samples. The bioavailability of the protein was also examined and the results are presented, along with the composition of the amino acids, in Table 2. The digestibility of proteins and bioavailability of their constituent amino acids is an important factor which determines the protein quality (Suman *et al.,* 1992; Hsu *et al.,*1977). This is true as all proteins are not digested, absorbed and utilised to the same extent. The multienzyme *in vitro* procedure has shown good correlation with *in vivo* methods. As per observations, the male crickets recorded protein digestibility of 90.7± 1.4%, while the female crickets had protein digestibility of 94.7± 1.4%. These values are higher than those already reported for legumes and animal protein sources (Adebowale *et al.*, 2005; Lawal and Adebowale, 2004; Adebowale and Lawal, 2003; Oshodi *et al.,* 1995; Robinson, 1987; Pellet and Young, 1980; Hsu *et al.,* 1977).

Table 3. Provisional amino acid scoring pattern and amino acids scores of the male and female crickets (*Gryllidae* sp)

Amino acid	FAO/ WHO level*	Amino acids content		Amino acids score**	
		Present work		Present work	
		Male	Female	Male	Female
Isoleucine	40	55.8	50.9	1.40	1.27
Leucine	70	79.6	71.5	1.14	1.02
Lysine	55	70.1	73.4	1.27	1.33
Methionine +cystein	35	42.1	70.1	1.20	2.00
Phenyalanine +tryptophan	60	88.9	116.3	1.48	1.94
Threonine	40	49.6	41.7	1.24	1.04
Valine	50	70.9	84.7	1.42	1.69

*suggested level (FAO/WHO, 1985); **amino acids score = mg amino acids per g test protein/mg amino acids per g reference protein

The crude fat content of the cricket samples, as reported in Table 1, indicate that the male crickets contained 7.25%, while the female crickets contained 10.78% crude fat. These values are lower than the values obtained for every developmental stage of the variegated grasshopper as reported by Adedire and Ayesanmi (1999), and Ajakaye and Banwo (1990). However, it was higher than those reported for animal foods, such as periwinkle (*Pachilania byronensis*), Crayfish (*Paramontes* sp), snail (*Vivapara quadarato)* and dogwhelk (*Thais cattifera*) (Udoh *et al.,* 1985; Mba, 1980).

The crude fibre values were fairly high, while the carbohydrate values were much lower than the values reported by earlier authors (Udoh *et al.,* 1995; Ajakaye and Bawo,1990). The composition of the carbohydrates fraction is presented in Table 4. Sugars (glucose, sucrose, fructose and maltose) were detected in concentrations between 0.7-6.1%. The carbohydrates fraction contained between 85.9-88.0% glycogen.

The total ash contents of the cricket samples were generally low (5.68% for the male crickets and 4.31% for the female crickets). These values are comparable to the values obtained for the termite, *Trinevitermes germinatus,* and *Thais cattifera*

Table 4. Percentage carbohydrates in the male and female crickets (*Gryllidae* sp)

Carbohydrates	Composition (%)*	
	Male	Female
Sugars	6.1 ±0.3	5.2 ± 0.2
Glucose	4.1 ±0.1	2.1 ±0.0
Sucrose	0.7 ±0.0	0.2 ± 0.0
Fructose	0.9 ±0.0	1.0 ± 0.0
Maltose	3.7 ±0.1	4.4 ± 0.4
Polysaccharides**	85.9 ±1.5	88.0 ± 2.6

*mean±sd of three determinations; **carbohydrates expressed as stored glycogen

(Udoh *et al.*, 1985; Mba, 1980). The ash contents represented the mineral elements present in the samples. The ash contained a number of nutritionally valuable minerals. The Na/K retio in the ash was particulary favourable. It is desirable that the Na/K ratio should approach unity to prevent high blood pressure (Esuoso *et al.*, 1998). The results of mineral composition analysis are presented in Table 5. The concentration of minerals was generally low in both the male and female crickets. Lead and nickel contents were below the detection limits, while the concentration of manganese was below 0.9 mg/100 g.

The results of the functional properties of the cricket samples are shown in Table 6. The least gelation concentration of the crickets was 10.0%. This high value may be advantageous for some food products. It can thus be incorporated into foods which require gelling and thickening. The water absorption capacity of the crickets was 238.47%. This value is beneficial for food products where the retention of moisture is desirable during cooking, which include meat and baked products (Altchul and Wilcke, 1958). The African giant cricket may, therefore, be useful for these products. The oil absorption capacity was 202.1%. This value made the cricket samples appropriate for incorporation in food products involving fat absorption, such as bakery products.

The emulsion capacity and stability were 46.8% and 8.5%, respectively. The capacity of protein to aid the formation and stabilisation of emulsion is important for incorporation in foods, such as in cake-baking, coffee whiteners, milk mayonnaise, salad dressing, comminuted meat, and frozen desserts. The cricket samples may, therefore, be used in these food products. The foaming capacity and stability was fairly good. The effect of pH on the protein solubility is shown in Table 7. The lowest solubility was recorded at the pH value of 4.0, while the maximum solubility was noted at the pH values between 6.0 and 7.0. This is advantageous for incorporation in food products which require shightly acidic-neutral environments.

Table 5. Nutritionally valuable minerals and trace matals (mg/100 g) of male and female crickets (*Gryllidae* sp)

Minerals/ trace metal	Male	Female
Calcium	9.45	1.34
Sodium	60.18	73.87
Potassium	56.35	93.50
Magnesium	50.63	67.69
Phosphorus	180.92	141.87
Iron	20.08	18.33
Zinc	1.46	2.75
Copper	nd*	nd
Manganese	<0.9	<0.9
Lead	nd	nd
Nickel	nd	nd

*nd = not detected (below detection limit)

Table 6. Some functional properties (%) of the large African crickets (*Gryllidae* sp)

Functional properties	Concentration (%)*
Least gelation concentration	10.00 ± 0.00
Water absorption capacity	238.47 ± 0.05
Oil absorption capacity	202.05 ± 0.10
Emulsion capacity	46.81 ± 0.00
Emulsion stability	8.50 ± 0.10
Foaming capacity	6.00 ± 0.00
Foaming stability (after 2 h)	3.05 ± 0.02

*mean±sd of three determinations

Table 7. The effect of pH on the protein solubility of the large African crickets (*Gryllidae* sp)

pH value	Protein solubility (%)
1	25.84
2	24.50
3	19.38
4	12.92
5	19.38
6	28.84
7	28.90
8	27.48
9	27.01
10	26.20
11	25.95
12	27.30

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References

Adebowale, K.O., Lawal, O.S. 2003. Foaming, gelation and electrophoretic characteristics of mucuna bean (*Mucuna pruriens*) protein concentrates. *Food Chem.* **83:** 237-246

Adebowale, Y.A., Adeyemi, A., Oshodi, A.A. 2005. Variability in the physicochemical and antinutritional attributes of six mucuna species. *Food Chem.* **89:** 37-48.

Adedire, C.O., Ayesanmi, A.F. 1999. Proximate and mineral composition of the adult and immature forms of *Zonocerus variegatus* L (Acridoidae: Pygomorphidae). *Biosci. Res. Comm.* **11:** 121-126.

Ajakaiye, C.O., Bawo, A. 1990. Comparison of the chemical composition of *Trinevitermes germinatus* with that of its feed. *Nigerian J. Entomol.* **11:** 90-99.

Altchul, A.M., Wilcke, H.L. 1958. New protein foods. *J. Food Sci. Technol.* **54:** 90-95.

AOAC. 1990. *Official Methods of Analysis,* 15th edition, Association of Official Analytical Chemists, Washington DC, USA.

Chapman, R.F. 1962. The ecology and distribution of grasshoppers in Ghana. *Proc. Zoological Soc. London* **139:** 1-66.

Coffman, C., Garcia, V.V. 1977. Functional properties of protein isolate from mug beans. *J. Food Technol.* **12:** 473-484.

Daramola, A.M. 1974. A review of the pests of cola bean. *Nigerian J. Entomol.* **1:** 21-29.

Esuoso, K.O., Lutz, H., Kutubuddin, M., Bayer, E. 1998. Chemical composition and potentials of some underutilized tropical biomass. I. *Telfairia occidentalis*. *Food Chem.* **61:** 487-495.

Esuoso, K.O., Odetokun, S.M. 1995. Proximate chemical composition and possible industrial utilisation of *Blighia sapida* seeds and seed oils. *Riv. Ital. Sostanze Grasse* **72:** 311-313.

FAO/WHO. 1985. Energy and protein requirements. *Report of the Joint Expert Consultation,* WHO Technical Report Series, # 724, Geneva, Switzerland.

Hewwitt, G.B. 1980. Plant phenology as a guide in timing grasshopper control efforts in Montana rangeland. *J. Range Magmt.* **33:** 297-299.

Hsu, H.W., Vavak, D.L., Satterlee, L.D., Miller, C.A. 1977. A multienzyme digestibility technique for estimating protein digestibility. *J. Food Sci.* **42:** 1269-1273.

Kaufmann, T. 1965. Observations on aggregate migration and feeding habits of *Zonocerus veriegatus* in Ghana (Othoptera: Acridoidae). *Annals Entomol. Soc.* **58:** 426-436.

Lawal, O.S., Adebowale, K.O. 2004. Effect of acetylation and succinylation on the solubility profile, water absorption capacity, oil absorption capacity and emulsifying properties of mucuna bean (*Mucuna pruriens*) protein concentrates. *Nahrung. Food* **48:** 129-136.

Mba, A.U. 1980. Chemical composition of some local sources of protein foods for man. *Nigerian J. Nutr. Sci.* **1:** 142-147.

Narayana, K., Narsinga, R.M.W. 1982. Functional properties of raw and heated processed winged bean (*Psophocarpus tetraglobulus*). *J. Food Sci.* **42:** 534-538.

National Research Council. 1974. Recommended daily dietary allowance RDA. *Nutr. Rev.* **31:** 373-395.

Oshodi, A.A., Ipinmoroti, K.O., Adeyeye, E.I., Hall, G.M. 1995. Amino and fatty acids composition of African yam bean (*Spenostylis stenocarpa*) flour. *Food Chem.* **53:** 1-6.

Pellet, P.L., Young, V.R. 1980. Nutritional evaluation of protein foods. In: *Report of Working Group Sponsored by the International Union of Nutritional Sciences and the United Nations University World Hunger Programme,* Food and Agriculture Organization, Rome, Italy.

Robinson, L. 1987. *Food Biochemistry and Nutritional Value,* pp. 1-120, Longman Scientific and Technical Publishing Company, London, UK.

Sathe, S.K., Salunkhe, D.K.1981. Isolation, partial characterisation of black gram (*Phaseolus vulgaris L)* starch. *J. Food Sci.* **46:** 617-621.

Suman, C.N., Monterio, P.V., Ramanchandra, G., Sudharshana, D. 1992. *In vitro* enzyme hydrolysis of the storage protein of Japanese millet (*Echinochloa frumantacea). J. Sci. Food Agric.* **58:** 505-509.

Toye, S.A. 1982. Studies on the biology of grasshopper pest, *Zonocerus variegatus* L (Othoptera: Pygomorphidae) in Nigeria 1911-1981. *Mini Review Insect Science and Applications* **3:** 1-7.

Udoh, A.P., Effiong, R.I., Edem, D.O. 1985. Nutrient composition of dogwhelk (*Thais cattifera*): a protein source for humans. *Trop. Sci.* **35:** 64-67.

Vogel, A.I. 1978. *A Textbook of Qualitative and Quantitative Inorganic Analysis*, 4th edition, Longmann, London, UK.

Yasumatsu, K., Sawada, K., Moritaka, S.M., Salei, M., Toda, J., Wada, T. Ishii, K. 1972. Whipping and emulsifying properties of soybean products. *Agric. Biochem.* **36:** 719-727.