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EVALUATION OF ESSENTIAL NUTRIENTS IN EDIBLE LOCUSTS AND GRASSHOPPERS IN KANO METROPOLIS

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ABSTRACT

The present study was conducted to evaluate the nutritional composition of edible locusts and grasshoppers sold and consumed in Kano metropolis, Northwestern Nigeria. Two species of locusts: (Schistocerca gregaria and Locusta migratoria) and two species of grasshopper (Zonocerus variegatus and Ornithacris turbida) were procured from Rimi market Kano. Proximate, mineral and amino acids compositions of the samples were analyzed using standard methods. The results obtained revealed a significant difference (P≤0.05) in the amount of proteins, fats, ash, carbohydrates and moisture contents. Similar result is found in the mineral compositions in terms of Na, Mg, K, Ca, Cu, Zn and Fe. More so, the amino acid composition of the samples was found to be significantly different (P≤0.05). No significant difference was found in the fibre contents. However, high protein (53.23-67.88%), fats (7.55-18.77%) and carbohydrate contents (10.71-16.01%) were found among the insect samples. Similarly, the amount of essential amino acids such as: threonine, valine, methionine and leucine were higher among the insects. It is therefore concluded that, the edible grasshopper and locust contain significant amount of nutritional components that can be beneficial in combating malnutrition and be incorporated in diet therapy.

Keywords: Amino Acids, *BakinAsibiti*, Fatty Acids, *KurnaBabbanLayi*.

INTRODUCTION

Poverty, malnutrition and hunger are the major indices threatening food security in the African continent especially, areas located South of the Sahara. These three indices hinder the attainment of the pillars constituting food security described by the CFS (2009). There is an increasing concern upon the increase rate of food crises and pricing in Nigeria with subsequent increase rate of food security via high increase in the price of animal protein sources as fish and meat were far from the reach of a common man. The menace of malnutrition coupled with increasing demand and consequent high cost of conventional proteins from animals, plants and aquatic sources have created the need for sustainable alternatives, particularly unconventional sources of proteins such as snails and edible insects which include cricket, termites, locust and edible larva. Protein supplementation from these sources also increases the income of people in the urban and rural areas (Ezeama *et al*., 2007). In an attempt to streamline the problem of malnutrition and hunger within the context of overwhelming human population increase as well as managing the health risks associated with meat consumption, entomophagy (act of eating insects as food) is highly recommended

(FAO, 2013) as an alternative. Consumption of edible insects is therefore seen as an important tool in improving the supply of vital nutrients to man in Nigeria (Alamu *et al*., 2013).

Insects have played an important part of human nutrition in Africa, Colombia, Venezuela, Asia and Latin America (Ruddle, 2006; Chavunduka, 2010). Insects and meat play the same role in the human body as insects remain a vital and preferred food and an essential source of protein, fat, minerals and vitamins (Durst and Shono, 2010). Some edible insects have nutritional value that can be compared with that of meat and fish (DeFoliart, 1992). The consumption of insects as food reduces serum cholesterol and serves as a homeostatic agent of tissue repairs and for accelerating the healing of wounds due to its chitin content (DeFoliart, 2007; Goodman, 2011). Other researchers (Banjo *et al*., 2006; Paul *et al*., 2016; Clarkson *et al*., 2018) in their review of different edible insects also reported the presence of various nutrients, micronutrients, proteins and vitamins in various edible insects. Rumpold and Schlüter (2013) reported that 236 of the more than 2000 edible insect species provide satisfactory energy and protein, meet amino acid requirements for humans, high in monounsaturated fatty acids and polyunsaturated fatty acids and rich in several minerals and vitamins (Christensen *et al*., 2006). Encouraging grasshopper and locust entomophagy would be a very good strategy for pest management as these insects seen as pests would now be regarded as source of much needed protein (Jacob *et al*.,2013).

Locusts and grasshoppers are mostly sold in Kano metropolis and people, especially women and children are major consumers. Although, the chemical compositions of edible grasshoppers and locusts have been evaluated by several workers, little information is known about the nutritional values of these insects consumed in Kano. More so, with increasing consumer preference for high-quality protein in Nigeria and the desire to combat hunger and malnutrition in the country, the nutritional composition of these edible insects needs to be explored to provide first-hand information that will assist in insects farming to meet the market demand and achieve sustainable development goals and add to the existing data of food composition tables. This study therefore is aimed at evaluating the nutritional composition of dried locusts and grasshoppers sold in Kano metropolis, northwestern Nigeria.

MATERIALS AND METHODS

Samples Collection

The locusts and grasshopper samples were procured from Rimi market in Kano metropolis: Kano state Nigeria. The market is mostly patronized by women and entomophagy in Kano is associated with women and children. The samples were collected in sterile polythene bags and labeled appropriately. The samples were taken to the Department of Crop Protection, Ahmadu Bello University Zaria for identification. Two species of locusts were identified as *Schistocerca gregaria* (Orthoptera: Acrididae) and *Locusta migratoria* (Orthoptera: Acrididae) and two species of grasshopper: *Zonocerusvariegatus* (Orthoptera: Pyrgomorphidae) and *Ornithacristurbida* (Orthoptera: Acrididae) were taken to the Food Analysis Laboratory of the Department of Food Science and

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Technology, Kano University of Science and Technology, Wudil, for nutritional analyses. The samples were further oven dried at a temperature of 105±2°C for 7 hours and ground using a mill to powder for the analyses. The samples were divided into three portions for proximate, minerals and amino acids analyses respectively. The samples were arranged in a Completely Randomized Design (CRD) with three replications.

Proximate Analysis

The insect samples were analyzed according to the official methods of analysis recommended by the Association of Official and Analytical Chemists (AOAC, 2000). Crude fat, crude fibre, ash and moisture contents were assayed by proximate analyses. Nitrogen content was estimated by the AOAC Kjeldahl method. Crude protein content was subsequently calculated by multiplying the nitrogen content by a factor of 6.25 as described by (AOAC) formula. The carbohydrate content of the samples were determined as the difference obtained after subtracting the values of protein, fat, fiber, ash and moisture from the total dry matter as reported by Onyeike *et al*. (1995). This method involves adding the total values of crude protein, crude fat, crude fibre, moisture and ash constituents of the sample and subtracting it from 100:

Percentage carbohydrate = 100 - (% moisture+%ash+%crude protein+%crude fat+%crude fibre).

Mineral Contents Analysis

The mineral contents of the insect samples were extracted using dry ashing method as described by Nielsen (2002). One gram (1 g) of each sample was weighed in a crucible, burned on hot plate until the smoke subsided completely and then ashed in a muffle furnace at 500^{o}C for 3 hours. The crucible was transferred into a desiccator and allowed to cool. The ashed sample was transferred into a 250 ml beaker to which 15 ml of concentrated hydrochloric acid and 5 ml of concentrated nitric acid were added. The dissolved ashed sample was evaporated to dryness on a hot plate set at 100 ^{o}C. 5 ml of 5 M hydrochloric acid was added and transferred to 100 ml standard volumetric flask. It was then made up to mark with distilled water and filtered. The elemental analyses of the prepared samples were performed using Atomic Absorption Spectrometer.

Amino Acid Profiles Determination

The Amino acid profiles of the grasshopper and locust samples were determined using the methods described by Benitez (1989). The samples were defatted using chloroform and methanol mixture in the ratio of 2:1 after 4 grams of each sample was placed in soxhlet extraction thimble and refluxed with gentle heating for 15 hours (AOAC, 2000). About 0.2 gm of each of the defatted sample was weighed into glass ampoule, 7 mL of 6NHCL was added and oxygen was expelled by passing nitrogen into the ampoule. The glass ampoule was then sealed with Bunsen burner flame and put in an oven preset at 105°C±5°C for 22 hours. The ampoule was allowed to cool before broken open at the tip and the content was filtered to remove the humins. Tryptophan, which was destroyed by 6 NHCL was recovered using alkaline hydrolysis method with 4.2 m sodium hydroxide as described by Maria *et al*. (2004). The filtrate was then evaporated to dryness using rotary evaporator. The residues were dissolved with 5 ml acetate buffer (pH 2.0) and stored in plastic specimen bottles kept in the refrigerator until use. Sixty micro litre (60 µl) of the hydrolysate was loaded into the PTH Amino Acid Analyzer. This was dispensed into the cartridge of the analyzer which had been designed to separate the free acidic, neutral and basic amino acids of the hydrolysate concentration of the amino acids to produce a profile.

Statistical Analysis

The data obtained were analyzed using Analysis of Variance (ANOVA) using SAS package (SAS, 2003) with Least Significant Difference. The level of significance was set at $p < 0.05$.

RESULTS

The result for the proximate composition (Table 1) revealed a significant difference ($P \leq 0.05$) in ash, fats, proteins and carbohydrates contents. No significant difference is found in the fibre contents. The *Z. variegatus* has the highest protein (67.88%), ash (5.16%) and fibre contents (2.61%) than the remaining insects species studied while *L. migratoria* has highest fat and moisture contents of 18.77% and 7.17% respectively. However, the protein contents in the insects range between 53.23% in *L. migratoria* to 67.88% in *Z. variegatus*, fats contents range between 7.55-18.77% and carbohydrate contents range between 10.71-16.01%.

The result for the mineral composition in edible locusts and grasshopper sold in Kano is presented in Table 2. The result showed significant differences ($P \leq 0.05$) in the mineral contents of all the insects' samples. Potassium is the most abundant mineral (298.36-378.15mg/100g). *Zonocerusvariegatus* has the highest amount of minerals. All the grasshopper species were found to have high amount of minerals compared to their locust counterparts.

Table 1: Proximate Composition of Edible Locusts and Grasshoppers Vended in Kano

Sample	% Moisture	% Ash	% Fat	% Protein	% Carbohydrate	% Crude Fiber
Locusta migratoria	7.17 ±0.04$^{a*!}$	3.3±0.32^{c}	18.77±0.05^{a}	53.23±0.73^{c}	15.48±0.02^{a}	2.05±0.07^{a}
Zonocerusvariegatus	6.09±0.09^{b}	5.16±0.01^{a}	7.55±0.21^{c}	67.88±0.55^{a}	10.71±0.23^{c}	2.61±0.00^{a}
Ornithacristurbida	6.10±0.1^{b}	4.89±0.1^{b}	10.75±0.10^{b}	62.24±1.09^{b}	13.56±0.04^{b}	2.46±0.05^{a}
Schistocerca gregaria	6.78±0.02^{b}	3.5±0.7^{c}	17.10±0.04^{ab}	54.41±0.00^{c}	16.09±0.06^{a}	2.12±0.01^{a}

N.B: *[1] Value(s) with the same superscript(s) down a column are not significantly different (P=0.05)

Table 2: Mineral Composition of Edible Locusts and Grasshoppers (mg/100g) from Kano

Sample	Sodium	Magnesium	Potassium	Calcium	Cupper	Zinc	Iron
Locusta migratoria	0.24±0.00^{c}	13.37±0.08^{c}	298.36±1.56^{c}	27.61±3.51^{c}	0.74±0.02^{b}	13.24±0.17^{b}	13.21±2.04^{c}
Zonocerusvariegatus	0.32±0.02^{a}	19.45±0.01^{a}	378.15±2.08^{a}	36.14±3.02^{a}	0.80±0.00^{a}	18.23±1.16^{a}	18.62±1.02^{a}
Ornithacristurbida	0.28±0.05^{b}	15.06±0.12^{b}	321.24±3.13^{b}	29.32±3.74^{b}	0.72±0.00^{b}	17.11±1.82^{a}	15.24±1.62^{b}
Schistocerca gregaria	0.23±0.04^{c}	13.20±0.09^{c}	301.12±2.75^{c}	24.97±2.01^{d}	0.66±0.02^{c}	13.05±2.04^{b}	12.91±1.08^{c}

N.B: *[1] Value(s) with the same superscript(s) down a column are not significantly different (P=0.05)

The result for the amino acids profile in grasshopper and locust samples is presented in Table 3. The result showed significant difference ($P \leq 0.05$) in the amino acids

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contents of the samples. The results indicated the presence of nine essential amino acids (No. 1-9) and nine non-essential amino acids (No. 10-18). *Zonocerusvariegatus* has the highest amounts of essential amino acids and non-essential amino acids except histidine. The amount of amino acids in the insects is mostly in the following sequence: *Z. variegatus>O. turbida>L. migratoria>S. gregaria*. The amounts of amino acids in grasshoppers were significantly higher than those in locusts.

Table 3: Amino Acids Profile of Edible Locusts and Grasshopper from Kano

S/N	AminoAcid	*Locusta migratoria* (g/100g)	*Zonocerusvariegatus* (g/100g)	*Ornithacristurbida* (g/100g)	*Schistocerca gregaria* (g/100g)
1	Cystein	0.32±0.01^{c}	0.84±0.02^{a}	0.56±0.02^{b}	0.31±0.02^{c}
2	Isoleucine	0.53±0.02^{c}	1.67±0.01^{a}	0.84±0.02^{b}	0.49±0.01^{c}
3	Leucine	2.64±0.01^{c}	6.2±0.05^{a}	4.89±0.02^{b}	2.15±0.01^{c}
4	Lysine	1.35±0.01^{b}	2.08±0.02^{a}	1.46±0.01^{b}	1.26±0.00^{b}
5	Methionine	3.54±0.03^{b}	5.32±0.13^{a}	3.08±0.00^{b}	3.33±0.02^{b}
6	Phenylalanine	0.48±0.01^{c}	1.31±0.01^{a}	0.62±0.02^{b}	0.28±0.01^{d}
7	Threonin	11.70±0.02^{c}	22.31±0.24^{a}	16.46±0.04^{b}	8.64±0.04^{d}
8	Tryptophan	1.38±0.02^{c}	3.15±0.02^{a}	2.68±0.02^{b}	1.32±0.01^{c}
9	Valine	4.24±0.02^{c}	9.42±0.04^{a}	6.73±0.02^{b}	4.16±0.02^{c}
10	Alanine	4.31±0.01^{b}	5.64±0.02^{a}	5.15±0.01^{a}	4.22±0.02^{b}
11	Arginine	8.02±0.05^{c}	9.87±0.01^{a}	8.75±0.05^{b}	6.38±0.01^{d}
12	Aspertic Acid	0.51±0.01^{c}	0.72±0.01^{a}	1.06±0.01^{b}	0.31±0.01^{d}
13	Glutamic Acid	3.23±0.02^{c}	6.05±0.02^{a}	5.68±0.02^{b}	3.64±0.02^{c}
14	Glycine	6.52±0.06^{c}	11.78±0.03^{a}	10.45±0.04^{b}	6.02±0.01^{c}
15	Histidine	5.45±0.02^{c}	8.23±0.06^{b}	9.36±0.17^{a}	3.16±0.02^{d}
16	Proline	12.16±0.04^{b}	22.64±0.17^{a}	22.38±0.34^{a}	10.78±0.05^{c}
17	Serine	3.05±0.02^{c}	7.53±0.02^{a}	5.02±0.04^{b}	2.96±0.02^{c}
18	Tyrosine	7.25±0.01^{b}	13.32±0.04^{a}	12.96±0.05^{a}	5.35±0.02^{c}

N.B: Value(s) with the same letters across a row are not significantly different (P=0.05)

DISCUSSION

The proximate analysis of the four different insect species vended in Kano had suggested the relative importance of such insects as source of nutrients to the populace. The highest value of protein content of these insects reported by this study is higher than that of the beef carcass (16.5%) and venison (21.4%) as reported by FAO (2007), broiler chickens as reported by Souza *et al*. (2011) and that of some fish species such as *Clarias gariepinus* and

Cyprinus carpio (15.86%) as reported by Mahboob *et al*. (2019). The finding of this study confirmed the findings of DeFoliart (2002), Banjo *et al*. (2006) and Cerritos (2009) that the level of protein in insects is generally higher than those of conventional sources of proteins such as meat, dairy products and seeds. The presence of high protein content in grasshopper reported in the present work is in agreement to that of Oibiokpa *et al*. (2017) who reported grasshopper to have the highest protein content among some edible insects analyzed. The result from this study therefore revealed that grasshoppers and locusts are good sources of protein and the protein value falls within the range (15-81%) reported by Ramos-Elorduy *et al*. (1997) as crude protein content of insects. The fat content in grasshopper and locust can offer a high fat content for human diet among the communities practicing entomophagy. This can also be essential in the human diets as fat increases the palatability of foods by absorbing and retaining their flavors as stressed by Aiyesanmi and Oguntokun (1996). Fats are also vital in the structural and biological functioning of the cells and help in the transport of nutritionally essential fat-soluble vitamins.

More so, the values of carbohydrates in the insect species studied indicated their relative importance as energy source. This finding is in agreement with that of Haruna *et al*. (2014) who reported the carbohydrate contents of grasshopper to be 29.61% which is almost similar to the one reported by this study. The result of the carbohydrate content was higher than the values reported by Mousummi and Suman (2013). The high carbohydrate content can be attributed to the nature of chitinous exoskeleton of the two insect species. The crude fibre contents of the studied insects indicated that, insects are very good sources of food as they can be palatable and enhance digestion by maintaining internal distension for a normal peristaltic movement of the intestinal tract as reported by Ayoola and Adeyeye (2010).

The presence of adequate amount of mineral elements in grasshoppers and locusts is an indication of their relative importance in the development of bones and teeth. The presence of high amounts of potassium presented in this study agrees with the findings of Oibiokpa *et al*. (2017) who reported similar finding. The studied insects have adequate amino acid profile that meets the highly demanding preschooler WHO as stressed by Rumpold and Schluter (2015). The amino acid contents by the present study conformed to the values recommended by the United States Institute of Medicine as reported in Maia (2018) that each gram of protein food consumed should provide 25 mg of isoleucine, 51 mg of lysine; 47 mg of phenylalanine; 27 mg of threonine; 7 mg of tryptophan; 18 mg of histidine and 32 mg of valine. The high amino acids reported by this finding is also similar to that of Wang *et al*. (2007) who also reported high amino acid contents in insects. The adequate amount of lysine and threonine in these insects studied can help offset cereal-based diets (such as wheat, rice, cassava and maize) that are deficient in lysine and threonine as reported by Ozimek *et al*. (1985), while leucine and histidine have been reported to enhance the growth of infants and young children (Cameron and Hofvander, 1980). The amino acid profile presented in this study is similar to the one reported by Melo-Ruiz *et al*. (2015) from five species of grasshopper in Mexico.

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Grasshopper and locust entomophagy can therefore supply essential nutrients to man in order to combat malnutrition and food-deficiency related diseases. The variation in nutritional composition of the insect samples can probably be attributed to the variation in the source of the insects and the type of food eaten by the insects. This finding is in line with that of Ibarra-Herrera *et al*. (2020) who reported variation in nutritional composition of grasshopper fed with two different diets. Grasshopper and locust can be recommended for children, women (especially the expecting mothers) and old-aged people. The significant amount of nutrients contained in these insects make them good sources of raw materials for combating nutrients deficiency diseases in Nigeria and the world in particular. *Zonocerusvariegatus* is found to contain best nutritional qualities needed for growth and development and is therefore recommended.

CONCLUSION

It was concluded that grasshoppers and locusts contained essential nutrients that could be used in preventing nutrients-deficiency diseases. They can be included in the diets of children, expecting mothers, and the aged due to their availability and low cost to complement for malnutrition. *Zonocerusvariegatus* is recommended to be the best in nutritional qualities essential for consumption. The low moisture content implies that, it can be stored for long period of time. Thus, these insects can be recommended for diet therapy in nutrients deficient diseases.

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