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PROXIMATE AND ANTI-NUTRIENT COMPOSITION OF FOUR EDIBLE INSECTS IN AKWA IBOM STATE, NIGERIA

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ABSTRACT: A large number of insect species are potential sources of valuable nutrients for humans and animals. Inadequate information and advocacy on them seem to make this valuable source under-utilized in animal husbandry. This article gives the results of laboratory determination of proximate compositions and some anti-nutritional factors of four insects, viz: Cricket (*Gymnogryllus lucens*), Yam beetle(*Heteroligus meles*), Palm weevil (*Rhynchophorus phoenicis*) and grass-hopper (*Zonocerus variegatus*) commonly eaten by some people in South Eastern Nigeria. The results revealed that Crude Protein ranged between 26 to 51%; with Cricket having the highest value and Yam beetle the lowest. All the insects had a considerable low carbohydrate contents. However, the mean energy / caloric values ranged from 474 to 522 Kcal/Kg. Crude fat values were moderate, ranging from 32-20% with Yam beetle having the highest value and Palm weevil the lowest. The anti-nutrients of the four insects were generally low far below toxic level in man. Moisture, Ash and crude fiber were very low compared to fish meat and beef. These insects therefore, could serve as additional promising sources of protein and fat for our poultry and teeming population.

INTRODUCTION

The search for alternative sources of food nutrients remains a perpetual event as human population growth is dynamic and ever increasing. Under-exploitation and under-utilization of abundant alternative natural resources has now been recognized as one of the militating factors against nutrient glut as intended by the 'Creator'. The consumption of selected insects in diverse forms is a positive response to this imperative. Yoloye (1988) has reported that insects are the most successful prolific group in animal kingdom, constituting about 76% of known species of surviving animals. Bodenheimer in the early 50s also reported that insects have played an important part in Africa, Asia, and Latin America. Insects are recognized as valuable source of alternative animal protein for Zambia's rural population because meat from domesticated and wild animals are scarce and beyond their economic level (Mwizenge, 1993). Report by Goodman (1989), has it that chitin, an important insect component, can significantly reduce serum cholesterol and serve as haemostatic agent of tissue repairs and for accelerating the healing of burns and wounds.

Though some insects are pests, as they affect man and destroy valuable materials and crops, edible insects are important dietary components in many developing countries. Ene (1963) has listed locust, termites, ants, grasshopper, weevils, beetles, crickets, and caterpillars among commonly consumed insects in Nigeria. Most insects are known to contain phytic acid as the only prominent anti-nutrient, but Ekop (2004) has shown that this toxic component are easily detoxified during processing like – frying, boiling and roasting.

Studies in Nigeria show that most Nigerians have directly or indirectly consumed edible insects, although this is more prevalent in rural than urban areas. Some insects such as oysters, beetles grubs and termites are collected mainly by women and children; and according to Akingbohungbe (1988) grasshoppers and crickets are eaten mainly by children, as food. Children and pregnant women, especially *primigravida*, naturally relish the savour of roasted cricket and winged termites. Caterpillars are regular in the rural village menu but animal meat is rather a stranger (Muyay, 1981). The aversion to insects as human food among Europeans is nothing more than custom and prejudices as rightly asserted by Owen (1973). Generally, grubs of the palm weevil are fried and eaten in several parts of Western and Niger Delta regions of Nigeria, where active marketing and roadside- hawking are seen along Onitsha –Aba busy roads.

In Uganda, the larvae of many species of the larger beetles are sought and eaten but are not as popular and important, as termites and grasshoppers in their diet. Different ethnic groups in Africa, may consume insects based on prevalence and seasonal ubiquity of particular insects species. This helps to ameliorate the chronic or seasonal shortage of vertebrate protein in sub-Sahara Africa.

Food supply and nutritional status in many African countries are inadequate in quantity and quality. This contributes to the widespread of malnutrition in the continent (Kent, 2002). In almost every legume, especially beans and rice, we ingest some significant numbers of rice weevils *(Sitophilus oryzae*) larvae, and this has been suggested by Taylor (1975) to be an important source of vitamin. The consumption and usage of various insects for rituals and medicinal purposes are among the traditions and customs of the medieval African that has persisted till date. Paucity of literature data and information has not allowed fast wide spread of insects consumption as viable alternative source of food.

The thrust of this work is to determine the proximate composition of four popular edible insects available in Akwa Ibom state, Nigeria. The work will also ascertain with basic data, some anti-nutritional factors in these insects. The awareness will encourage continued consumption and exploitation of these alternative cheap sources of lesser-known food item.

Experimental

Ten identified samples of each edible insects- Cricket (*Gymnogryllus lucens*), Yam beetle(*Heteroligus meles*), Palm weevil (*Rhynchophorus phoenicis*) and grass-hopper (*Zonocerus variegatus*) were randomly collected using entomological nets, and some hand-picked from different locations in Akwa Ibom State. The main location of sampling areas include: University of Uyo main football field, Akwa Ibom State Polytechnic, Ikot Osura campus, Ikot Ekpene L.G.A., Abak football stadium, some school farms in Ikot Abasi, Eket and Oron towns. The study was conducted for a period of six months, March – September, 2010 in three batches. The specimen were killed as recommended by Banjo *et al*. (2006). The frozen samples were then allowed to de-froze at room temperature in the laboratory and finally oven-dried to constant weight at about 65ºC for 24 hours. Samples for moisture determination were not frozen for obvious reasons. Dry samples were sub-grouped according to their species. The wings and hairs were removed before being ground into powder with laboratory porcelain pestle and mortar. Each ground sample was stored in labeled air-tight plastic containers and preserved in air-dried-oven for laboratory analysis.

Samples digestion and dissolution was done according to the method described by Whiteside (1979), using dry- ashing/ digestion for solutions meant for titration experiments.

Proximate Composition Analysis: The methods and technique adopted for the analysis are those recommended by the association of Official Analytical Chemists, AOAC (1975) and AOAC (1999) Parameters determined were: % Moisture, Ash content, Crude protein; and caloric value was computed from these data using "At Water Factor" , by multiplying the factor for carbohydrate and protein by 4 each and that of fat by 9, excluding crude fiber then taking the sum of the products. Triplicate determinations were carried out and the mean with standard deviation are reported here. All the methods were verified for reproducibility by repeating standard- addition pilot experiments.

Anti- nutrient Determination: For anti-nutrient determination, the method of Dye(1956) was used for Oxalate; For Hydrocyanic acid content, method described by Krishna and Ranjhan,(1980) was followed. While Phytic acid was determined using the method of McCancee and Widdowson(1953).

i) Oxalate determination involved three steps- digestion, oxalate precipitation and permanganate titration, while tannic acid content was assayed spectrophotometrically at 500nm wavelength using vanillin-HCl reagent for colour development. Exactly 100mg of tannic acid in one litre of distilled water was used for standard calibration curve (AOAC 1975).

ii) Phytic acid was determined as Iron precipitate with the assumption that, Iron: Phosphorus molecular ratio is 4:6. See detailed calculation in McCancee and Widdowson (1953). The molecular formula of Phytic acid is $C_6H_{18}O_{24}P_6$ with molecular mass of 660g/mol.(iii)For HCN determination, alkaline sample solution was titrated with standard 0.02N AgNO3 to a permanent turbid KI indicator end point.
Note: 1 ml of 0.02N AgNO3 = 1.08 mg HCN. (AOAC, 1975)

Results and Discussion
Table 1 gives the percentage composition of the following parameters; Moisture, Ash, Fiber, Lipid, Crude protein, and Caloric value in Kcal/kg for the four insects studied

Table 1: Result of Proximate Composition Analysis(%)

Sample	Moisture	Ash	Fiber	Lipid	Protein	Carbohydrate	Caloric Value (Kcal/kg)
G. lucens (Cricket)	1.180_a ± 0.001	6.400_a ± 0.01	3.300_a ± 0.01	26.467_a ± 0.001	50.750_a ± 0.0005	13.083_a ± 0.001	493.535_a ± 0.000
H. meles (Yam beetle)	0.960_b ± 0.001	6.000_b ± 0.000	3.000_b ± 0.000	31.667_b ± 0.001	37.625_b ± 0.0005	21.707_b ± 0.001	522.335_b ± 0.000
R. phoenicis (Palm weevil)	1.130_c ± 0.001	4.800_c ± 0.01	2.200_c ± 0.01	20.366_c ± 0.001	49.876_c ± 0.001	22.759_c ± 0.001	473.83_c ± 0.01
Z. variegatus (Grass hopper)	1.031_d ± 0.015	4.300_d ± 0.01	2.500_d ± 0.01	23.633_d ± 0.001	44.625_d ± 0.001	24.942_d ± 0.001	490.965_d ± 0.00

*Mean of 3 determinations ± SD
●Mean values in each column with different subscripts(a,b,c,d) differ significantly ($\alpha = 0.05$, n=3)

A careful study of the data in Table I shows that *G. lucens* (cricket) has the highest (1.18) percentage moisture when compared with the values for other insects studied, while yam beetles has the least value of 0.90. The moisture content of the entire insects are generally low. This indicates that they can all be preserved for a reasonable period of time without the risk of microbial deterioration and spoilage. The long shelf-life promised here is an added advantage over other sources of protein like beef, egg, fish, which are easily prone to spoilage on careless keeping. There is a significant variation in mean values of moisture content of the four different insects at $\alpha = 0.05$; n=3.

The values (0.96-1.18%) obtained here are slightly lower than the value (3.41%) reported by Banjo *et al*.(2006) for cricket. This disparity might be due to the size, maturity (age) and location (habitat) of the samples collected for analysis. Ash content of the different insects ranged from 4.30 to 6.40% for grasshopper. The values differ significantly as indicated in Table 1. Values for other insects are higher, varying from 10.26 for *C. forda* to 5.39% for *T. germintus*. There is a consensus among researchers that ash content of a given sample correlates the mineral contents of the sample. It stands to suggest that the four insects studied here can give a fair source of mineral elements as earlier reported by Ene (1963).

Crude fiber content in the edible insects under study are 3.30 ± 0.01 for Cricket, 3.00 ± 0.00, 2.20 ± 0.01 and 2.50 ± 0.01 for yam beetle, palm weevil and grasshopper respectively. These are appreciably high and could be attributed to little amount of chitin found normally in insects, Oduor *et al*.(2008), have reported that chitin and chitosan yield differ with species. The physiological role of crude fiber in the body is to maintain an internal distention for proper peristaltic movement of the intestinal tract (Oduor *et al*., 2008). A diet very low in fiber, could therefore lead to constipation which might bring discomfort to the body system with running stool(Groff at al., 1999). Diets with high fiber content have been used for weight control and fat reduction, as they give a sense of satiety even when small food is eaten (Ekop, 2004).

The values obtained differed significantly ($P \geq 0.05$), n=3 from each other and varied widely with literature values for different species of insects studied. This is not surprising, as different species have different exoskeletons and structure. The results of crude fiber content (0.2-3.3%) of the four insects corroborate and compared favorably with those of Banjo *et al*.(2006) for similar species. From the above, these insects are good sources of crude fiber.

Lipid(Crude fat) provides the ready source of energy for the body. The crude fat contents obtained for the studied insects ranges from 31.67 – 20.37% with *H. meles* (Yam beetle) having the highest and *R. phoenicis*(Palm weevil) the lowest. However, the data in the study varied significantly among the four species. All the insects here can provide supplementary dietary fat in feed formulation for animal husbandry. The quality of this fat needs to be ascertained in future research, since high density lipoprotein (HDL) is preferred to low density lipoprotein (LDL) in the prevention of heart arrest. Usually, unsaturated fats has HDL while saturated fats is associated with LDL.

Crude protein values for the four insects are also tabulated in Table 1. The values ranged from 50.75 –37.63% for *G. lucens* (Yam beetle) having highest value followed closely by *Z. variegates* (Grasshopper, 49.87%), 44.63 for *R. phoenicis(*Palm weevil) and lowest is 37.625% for H. meles(Yam beetle). These values differ significantly ($P < 0.05$). The recommended dietary allowance is about 1g/kg body weight for adult, about 1.5 to 2g/kg for growing children, pregnant and lactating mothers (Angeleti, 1993). The values obtained in this work for the four insects are lower than those for perewinkle 55%; T. caltifera 56.44% ; reported by

Mba(1980). Insects can contribute effectively as alternative source of protein to meet the recommended human daily protein requirement of 23 – 56% stipulated by NRC (1980).

The amount of carbohydrate obtained for the insects were 13.084, 21.707, 22.76 and 24.94% for cricket, yam beetle, palm weevil and grasshopper respectively. These values are slightly higher than some literature (Dunkel, 1996) values for similar insects; e.g cricket, large grasshopper, red ant and giant water beetle: 5.1, 2.2, 2.9, and 2.1% respectively). The results when compared between the four different insects, differed significantly at 95% confidence level. Insects are therefore not a good source of carbohydrate as revealed in this work. Human adult need about 400 – 500g carbohydrate intake as starch.

The computed gross energy value for all the four insects are appreciably high. They are varying but generally higher than some literature for similar insects. The variation might stem from variation in the fat control which seem to be influenced by the age, sex and habitat of the species. The mean energy values with the standard deviation are as follows: Cricket 493.535 ± 0.00 > Yam beetle 522.353 ± 0.00 > 490.965 ± 0.001 > Palm weevil 473.830 ± 0.00. None of the insects when taken in isolation as diet can meet the recommended daily allowance of 2500 – 3500 kCal. These insects need to be taken along side with other food items or taken as snacks, tip-bits and delicacy. However, insects can contribute greatly to the caloric content of food.

Table 2: Results of Anti-Nutrient (mg/kg)

Sample	Hydrocyanide (HCN)	Total Oxalate	Soluble Oxalate	Phytate	Tannin
G. lucens (Cricket)	2.187_a ± 0.0005	13.20_a ± 0.005	8.80_a ± 0.005	0.283_a ± 0.0005	0.329_a ± 0.0003
H. meles (Yam beetle)	2.734_b ± 0.0013	28.40_b ± 0.004	22.00_b ± 0.29	0.28_a ± 0.004	0.379_b ± 0.0008
R. phoenicis (Palm weevil)	2.422_c ± 0.0005	17.60_c ± 0.005	13.20_c ± 0.005	0.289_b ± 0.0005	0.405_c ± 0.0003
Z. variegatus (Grass hopper)	3.203_d ± 0.0009	26.40_d ± 0.005	8.80_a ± 0.005	0.281_a ± 0.0005	0.430_d ± 0.0006

*Mean of 3 determinations ± SD

●Mean values in each column with different subscripts(a,b,c,d) differ significantly ($\alpha = 0.05$, n=3)

Table 2 shows the results of anti-nutrient determination in four different insects studied. The HCN content of *G. lucens, H. meles, R. ph*oenicis and *Z. variegatus* were 2.187/100g, 2.734/100g, 2.422/100g, and 3.203/100g respectively. These values differed significantly($P< 0.05$). HCN are highly toxic to animals. The lethal dose of HCN to human is considered to be 35mg(Oke 1969).

While NRC (1974) gave the toxic level to be between the range 50-200mg/100g. The HCN values obtained for all the samples showed that they are negligible, hence they are not toxic to humans when consumed as per HCN toxicity. High level of HCN has been implicated for cerebral damage and lethargy in man and animals (Akyildiz *et al*., 2010).

The result showed the total oxalate to be between 13.20mg/100g for cricket to 28.40mg/100g for yam beetle. Soluble oxalate were 8.80mg/ 100g, 22.00mg/100g, 13.20mg/100g, and 8.80mg/ 100g for *G. lucens*, *H. meles*, *R. phoenicis* and *Z. variegatus* respectively. The values of oxalate were exceptionally higher than other anti- nutrient values. The lethal dose of oxalate is between 200mg/100g and 500mg/100g (Pearson, 1973). With detoxification through processing, these edible insects are safe for consumption with respect to oxalate toxicity. The difference in the mean values of the four edible insects are statistically significant at $\alpha = 0.05$. Oxalates are known to sequester and precipitate some useful metallic elements, thus making them unavailable for adsorption in human system (Groff *et al*., 1995).

Phytic acid content of *G. lucens, H. meles, R. ph*oenicis and *Z. variegatus* were found to be 0.283, 0.28, 0.289, and 0.281mg/kg respectively. Phytate, like oxalates, limit the availability of some notable minerals like magnesium, iron, and even calcium (Groff *et al*., 1995). The values of Phytate obtained for the different edible insects were in trace amount and the value showed no significant difference between each other at $\alpha = 0.05$. The results are lower than what was obtained by other investigators. Considering the trace values in the edible insects, means that they could be consumed without any fear of harm to the human body in respect to phytic acid toxicity. Phytic acid has also been implicated in the removal of phosphorus and causing indigestion and flatulence in human system (Ndubuakaku *et al*., 1998).

Tannin contents obtained from edible insects were 0.329, 0.379, 0.405, and 0.430mg/kg for *G. lucens*, *H. meles*, *R. phoenicis* and *Z. variegatus* respectively. These values obtained were in trace amount and differed significantly at $\alpha = 0.05$. Tannins possess both toxic and therapeutic functions. They are toxic in that they coagulate protein (Groff *et al*., 1995). This toxicity can be removed by heating. Okon and Ekop (2008) had shown that boiling and fermenting can drastically reduce tannin in cowpea. The trace level of tannin contents in these edible insects is therefore considered to be below toxic level in humans. Recent studies have demonstrated that products containing chestnut tannins at low dosages (0.15-0.2%) in the diet can improve broiler chicken performance and wellbeing (Schiavone *et al*., 2007). The trace values of anti-nutrient content recorded for *G. lucens, H. meles*, *R. phoenicis* and *Z. variegatus* showed that they can be consumed without fear of toxicity. This result will encourage the incorporation of these insect into food feeds formulations. Tannins are capable of lowering available protein by antagonistic competition and can therefore elicit protein deficiency syndrome (Ekop, 2006).

The result of proximate analysis of edible insects studied showed that moisture content, ash, crude fiber, lipid, protein, carbohydrate and caloric value obtained, generally agreed with most reports by other authors investigating different insects from several parts of the world. All the insects studied were rich in protein, lipid and fiber. The anti-nutrient contents of the four edible insects studied, were observed to be generally low and within safe consumption levels. On the whole, result of this study has confirmed that these edible insects could contribute significantly to the recommended daily protein of 123 – 56% stipulated by NRC(1989). Based on the results of this work, it may be concluded that identified crickets, grasshoppers, yam beetles and palm weevils are non-toxic edible insects, rich in protein and caloric values. Their continued consumption is, therefore, advocated and encouraged in solving the problem of malnutrition among the less-privileged in this part of Nigeria in particular, and the world at large where need arises.

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