Nutritional Evaluation of Some Edible Insects Collected from Ekiti State University, Ado-Ekiti, Nigeria

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DOI: https://doi.org/10.68050/JAMS.2026.946

Received: 28 October 2026; Accepted: 02 November 2026; Published: 10 November 2026

ABSTRACT

Edible insects are highly rich sources of protein, healthy fats, dietary fibre, and essential minerals. Their nutritional composition supports human health and emphasizes their importance in sustainable diets. They are one of the most affordable sources of animal protein, and their consumption is often encouraged as an alternative for low-income populations who cannot afford fish or other conventional animal proteins. This research evaluates the proximate and mineral composition of some edible insects found at Ekiti State University, Nigeria. Proximate composition was determined using the standard AOAC method; mineral composition was determined using the Atomic Absorption Spectrophotometric method, and results were reported as Mean ± Standard error. The results revealed that seven edible insects were found in the study area identified as *Anaphe venata, Zonocerus variegatus, Cirina forda, Apis mellifera, Macrotermes nigerensis, Orycetes boas* and *Rhycophorus phoenix.* The study further revealed that the seven insects contained appreciable amounts of proximate constituents and minerals. The results showed that there were significant differences at $P<0.05$ in the values obtained for Moisture, Protein, Ash and Fat content in all the sampled insects. The results revealed that *Zonocerus variegatus* had the highest protein content 42.74% while *Orycetes boas* had the least (20.50%). *Orycetes boas* had the highest crude fibre content (10.50%), while *Macrotermes nigerensis* had the least (5.17%). *Cirina forda* had the highest carbohydrate content (29.96%), while *Rhyncophorus phoenics* had the least (11.10%). The mineral content results showed that significant differences exist at $P<0.05$ in the values obtained for calcium, zinc, magnesium and sodium content in all the sampled insects. It is evident from this study that these edible insects are rich in protein and carbohydrates; they are good sources of minerals such as calcium, zinc, magnesium and iron, which are essential for normal development and growth. However, the prevalent issue of malnutrition among children may be resolved through the incorporation of these edible insects into the diet, as they provide an alternative and sustainable source of protein that may contribute to improved nutritional well-being.

Keywords: Edible insects, Proximate, Minerals, Nutritional composition, Ekiti State.

INTRODUCTION

The Class Insecta are the most abundant and diverse organisms found in virtually every habitat on Earth. They offer a sustainable and secure alternative source of animal-based food for meeting dietary needs (Hancz *et al.,* 2020). Due to their abundance, diversity, and adaptability, insects are regarded as one of the most successful animal groups on Earth. They serve as traditional foods among indigenous people, especially in Africa, Asia, and Latin America (Van Huis *et al*., 2013). The eating of edible insects, which is known as entomophagy, began about 7000 years ago (Ramos-Elorduy, 2009). Edible insects are considered nutritious food and are the ingredients of most dishes in Nigeria and around the world. Insects are considered an affordable protein source; insect consumption has been widely encouraged, as it serves as a valuable dietary alternative for people who cannot afford conventional protein sources such as fish and meat.

Insects have been recognized as an important protein source, minerals, vitamins and fats in many countries. Insects are tasty, nutritious, and high in protein (Hunts *et al.,* 2020). Insects are considered a stable food because they are easy to find, occupy little space, and have great nutritional benefits (Abril *et al*., 2022).

Beyond their nutritional value, edible insects serve as an important source of income in Nigeria and across Africa, where they are gathered from the wild and traded in markets. Insect species such as Locusts, termites, ants, grasshoppers, weevils, beetles, and crickets, among others, have been used as food and are commonly consumed in Nigeria (Alamu *et al.,* 2013). Insects are consumed as delicacies in many parts of the world, particularly in tropical regions. It is so disheartening that most people are ignorant about the nutritional values of these insects. Malnutrition has been recognized as a major challenge, especially in developing countries (Dukhi, 2020). Children are vulnerable to sickness due to inadequate diets, lack of protein and other nutritional requirements, thereby leading to sickness, which may eventually lead to death.

Considering their abundance and nutritional value, edible insects can contribute significantly to overcoming malnutrition in tropical regions. Consequently, there is a need for intensified research into affordable alternative sources of nutrients to support food security and improve nutrition. This research provides valuable dietary information on the nutrients required to maintain good health and enhance the overall well-being of individuals and encourages the consumption of edible insects, which could be a means to combat malnutrition problems. Although insects are recognised as potential sources of essential nutrients, their nutritional benefits have been inadequately explored. Therefore, this study aims to provide valuable data on their nutrient composition and dietary significance.

MATERIALS AND METHODS

Study location

The study was carried out at Ekiti State University, Ado-Ekiti, Nigeria. Ekiti State is geographically located between longitudes 40°51′ and 50°451′ East of the Greenwich meridian and latitudes 70°151′ and 80°51′ north of the Equator.

Collection and Preparation of Samples

Seven insect species; *Anaphe venata, Zonocerus variegatus, Cirina forda, Apis mellifera, Macrotermes nigerensis, Orycetes boas,* and *Rhycophorus phoenix* were collected from the following locations: The University Football Field, Teaching and Research Farm, Nursery, and Plantation sites. The insects were collected by hand-picking and sweep nets. Samples collected were taken to the Entomological Laboratory at the Department of Zoology, Ekiti State University, Ado Ekiti, for taxonomic identification.

The insects were rinsed with distilled water and sun-dried for one week; the dried insects were blended into powdered form using a mortar and pestle. The samples were well labelled and stored in sealable nylon bags until analysis

Proximate Composition determination

The moisture, crude fat, crude protein, crude fibre, ash, and total carbohydrate contents of each insect sample were determined using the methods of the Association of Official Analytical Chemists (AOAC, 2010). For Moisture content determination, 2 g of each sample was weighed, transferred into a crucible and oven-dried at 105°C until constant weight was achieved. Fibre content determination was carried out by defatting the samples with petroleum ether digestion. Fat content was determined after petroleum ether extraction in a Soxhlet apparatus for 1 hour. Ash content was determined by incinerating the samples in a muffle furnace at 550°C for 6 hours. Crude protein determination was carried out using the Kjeldahl method. The total nitrogen was multiplied by a conversion factor of 6.25.

Protein (%) =Nitrogen (%) × 6.25

Carbohydrates were obtained by difference:

Carbohydrate (%) = 100 - (% Moisture + % Protein + % Fat + Fibre + % Ash).

Mineral content determination

Mineral contents such as sodium, magnesium, iron, calcium, and zinc were determined. The minerals were extracted using the dry-ashing method as described by Nielsen (2002). Magnesium, Iron, Calcium, and Zinc were estimated using an atomic absorption spectrophotometer (AAS), while Sodium was estimated using a flame photometer.

Statistical Analysis

Data were subjected to Analysis of Variance (ANOVA) to determine significant differences between the insect samples at $P < 0.05$. Duncan's Multiple Range Test (DMRT) was used to separate the means where significant differences exist. All analyses were performed in triplicate. Results were expressed as mean ± standard error.

RESULTS

The order, common name and consumption stage of edible insect species recorded within the Ekiti State University campus are presented in Table 1. Seven (7) insect species (*Macrotermes nigeriensis* (Winged termite), *Orycetes boas* (Scarab beetle), *Cirina forda* (Pallid emperor), *Anaphe venata* (African silk worm), *Rhyncophorus phoenics* (Palm weevil), *Zonocerus variegatus* (Grasshopper) and *Apis mellifera* (Honey bee) belonging to five (5) Orders (Isoptera, Coleoptera, Lepidoptera, Orthoptera and Hymenoptera) were identified.

Table 1: Order, common name and consumption stage of edible insects found in Ekiti State University Campus

ORDER	FAMILY	SCIENTIFIC NAME	COMMON NAME	CONSUMPTION STAGE
Isoptera	Termitidae	*Macrotermes nigeriensis*	Winged termite	Adult
Coleoptera	Scarabaeidae	*Orycetes boas*	Scarab beetle	Larva
Lepidoptera	Saturnidae	*Cirina forda*	Pallid emperor	Larva
Lepidoptera	Notodontidae	*Anaphe venata*	African silkworm	Larva
Coleoptera	Curculionidae	*Rhyncophorus phoenics*	Palm weevil	Larva
Orthoptera	Pyrgomorphidae	*Zonocerus variegatus*	Grasshopper	Adult
Hymenoptera	Apidae	*Apis mellifera*	Honey bee	Larva, Pupae

The proximate composition of the insect species is shown in Table 2. The results showed that there were significant differences at $P<0.05$ in all the values obtained for fat and protein contents of the insects. The results showed that *Zonocerus variegatus* had the highest protein content (46.58%), while *Orycetes boas* had the least (20.50%). The results on crude fibre show that *Orycetes boas* had the highest value (10.50%) while *Macrotermes nigeriensis* had the lowest value (5.17%), the crude fibre content values of *Macrotermes nigeriensis* and *Apis mellifera, Anaphe venata* and *Zonocerus variegatus* were not significantly different at $P<0.05$. C*irina forda* had the highest Carbohydrate content (29.96%), while *Rhyncophorus phoenics* had the least (11.10%). The results showed that there were no significant differences at $P<0.05$ between the values obtained in the carbohydrate contents of *Zonocerus variegatus* and *Orycetes boas.*

Table 2: Proximate composition of edible insect species

Samples	Moisture	Fat	Ash	Protein	Crude fibre	Carbohydrate
A	8.17 ± 0.09^{g}	7.64 ± 0.04^{f}	4.86 ± 0.06^{d}	42.74 ± 0.14^{b}	7.16 ± 0.05^{d}	29.43 ± 0.09^{b}
B	8.51 ± 0.09^{f}	10.08 ± 0.04^{d}	3.27 ± 0.06^{g}	46.58 ± 0.14^{a}	7.10 ± 0.05^{d}	24.42 ± 0.09^{d}
C	10.14 ± 0.09^{e}	6.89 ± 0.04^{g}	6.17 ± 0.06^{b}	38.76 ± 0.14^{d}	8.08 ± 0.05^{b}	29.96 ± 0.09^{a}
D	12.27 ± 0.09^{d}	12.45 ± 0.04^{c}	5.10 ± 0.06^{c}	42.41 ± 0.14^{c}	5.21 ± 0.05^{e}	22.56 ± 0.09^{e}

E	14.48 ± 0.09^{c}	18.17 ± 0.04^{a}	4.07 ± 0.06^{f}	32.90 ± 0.14^{e}	5.17 ± 0.05^{e}	25.21 ± 0.09^{c}
F	25.26 ± 0.09^{b}	9.52 ± 0.04^{e}	9.75 ± 0.06^{a}	20.50 ± 0.14^{g}	10.50 ± 0.05^{a}	24.47 ± 0.09^{d}
G	37.91 ± 0.09^{a}	16.52 ± 0.04^{b}	4.66 ± 0.06^{e}	22.31 ± 0.14^{f}	7.50 ± 0.05^{c}	11.10 ± 0.09^{f}

Values in the same column followed by the same letter are not significantly different (P < 0.05).

A = *Anaphe venata,* B = *Zonocerus variegatus,* C = *Cirina forda,* D = *Apis melifera,* E= *Macrotermes nigerensis,* F = *Orycetes boas,* G = *Rhyncophorus phoenics*

The mineral composition of the insect species is shown in Table 3. There were significant differences at P<0.05 in all the values obtained for magnesium, calcium, and zinc contents of the insects. The results showed that *Macrotermes nigeriensis* had the highest sodium content value (81.15 mg/100g), while *Zonocerus variegatus* had the lowest value (43.30 mg/100g). *Orycetes boas* had the highest calcium content value (1214.00mg/100g), while *Apis mellifera* had the lowest value (54.95mg/100g). *Rhyncophorus phoenics* had the highest zinc content value (26.60mg), while *Zonocerus variegatus* had the lowest value (3.38mg), The result further showed that there were no significant differences at P<0.05 between the values obtained for Sodium and Iron content in *Cirina forda* and *Macrotermes nigerensis*

Table 3: Mineral composition of edible insect species

Samples	Na	Mg	Fe	Ca	Zn
A	67.85 ± 0.43^{c}	121.70 ± 0.36^{b}	12.77 ± 0.33^{e}	117.80 ± 2.11^{e}	8.21 ± 0.08^{e}
B	43.30 ± 0.43^{f}	32.75 ± 0.36^{g}	7.57 ± 0.33^{f}	124.95 ± 2.11^{d}	3.38 ± 0.08^{g}
C	80.30 ± 0.43^{a}	108.70 ± 0.36^{c}	18.46 ± 0.33^{d}	138.85 ± 2.11^{c}	6.46 ± 0.08^{f}
D	56.48 ± 0.43^{e}	37.55 ± 0.36^{f}	22.6 ± 0.33^{c}	54.95 ± 2.11^{g}	12.80 ± 0.08^{d}
E	81.15 ± 0.43^{a}	60.30 ± 0.36^{e}	18.20 ± 0.33^{d}	106.00 ± 2.11^{f}	14.60 ± 0.08^{c}
F	60.70 ± 0.43^{d}	79.56 ± 0.36^{d}	41.45 ± 0.33^{b}	1214.00 ± 2.11^{a}	19.45 ± 0.08^{b}
G	72.50 ± 0.43^{b}	124.76 ± 0.36^{a}	65.42 ± 0.33^{a}	818.00 ± 2.11^{b}	26.60 ± 0.08^{a}

Values in the same column followed by the same letter are not significantly different (P < 0.05).

A = *Anaphe venata,* B = *Zonocerus variegatus,* C = *Cirina forda,* D = *Apis melifera,* E = *Macrotermes nigerensis,* F = *Orycetes boas,* G = *Rhyncophorus phoenix*

DISCUSSION

The results from this study revealed the edible insects identified in the study area. Seven different species of edible insects were identified: Silk worm (*Anaphe venata),* Grasshopper (*Zonocerus variegatus),* Pallid emperor (*Cirina forda),* Honey bee (*Apis melifera),* Winged termites (*Macrotermes nigerensis),* Scarab beetle (*Orycetes boas),* Palm weevil (*Rhyncophorus phoenics).* These insects cut across the following orders: Lepidoptera, Orthoptera, Hymenoptera, Isoptera, and Coleoptera.

The results on proximate composition showed that the moisture content of all the insects was significantly different at P < 0.05. The moisture content of *Cirina forda* in the present study (8.17%) was lower than the value (38.54%) reported by Idowu *et al.,* (2019). However, the relatively low moisture content value obtained for *Anaphe venata*, *Zonocerus variegatus, Cirina forda,* and *Macrotermes nigerensis* suggests that they could be stored for a longer period of time without spoilage.

The fat content of *Macrotermes nigeriensis* was the highest among all the insect species; the fat content values obtained for *Rhyncophorus phoenics* and *Zonocerus variegatus* were lower than the values reported by Omotoso and Adesola (2018). The results indicated that *Macrotermes nigeriensis* is a good protein source in the human diet.

The protein content of *Zonocerus variegatus* was the highest, and the value recorded was higher than those reported by Anaduka *et al*., (2021) and Ojianwuna *et al.,* (2021). The protein content of *Zonocerus variegatus* compared favourably with the value obtained by Atowa *et al.,* (2021). The elevated protein content found in the insects indicates that they could be used to combat protein-energy malnutrition, as protein is essential for body growth and the repair of damaged tissues. Insects serve as a valuable source of protein and essential nutrients, thereby serving as a significant contributor to reducing food insecurity (Bernard and Womeni, 2017).

The comparatively high ash content of *Oryctes boas* proves that it might be a better source of minerals than all other insect species evaluated. However, the ash content of all the insects studied was higher than the value recorded by Egbeji *et al*. (2017). The value obtained in this study for *Rhyncophorus phoenics* is comparable to the value reported by Ojianwuna *et al.,* (2021).

The fibre content of *Orycetes boas* was the highest among the species. The fibre content value obtained for *Rhyncophorus phoenics* compared favourably with the value reported by Omotoso and Adesola (2018). Dietary fibre is essential for stimulating peristaltic activity and maintaining healthy intestinal function in animals. Fibre intake also helps to lower serum cholesterol and the risk of coronary diseases and breast cancer. (Nweze *et al.* 2021).

The carbohydrate content of *Cirina forda* was the highest, while *Rhyncophorus phoenics* was the least. The value obtained in this study for *Rhyncophorus phoenics* was higher than the value (7.42%) reported by Egbeji *et al.,* (2017). The value obtained for *Cirina forda* in the present study was found to be higher than the value reported by Oibiokpa *et al.,* (2017), who recorded a value of 13.25%. The result obtained in this study agrees with the findings of Ojianwuna *et al.,* (2021), who reported a value of 24.57% for *Macrotermes nigerensi*s. The result further revealed that these insects have varying proportions of carbohydrates. However, the carbohydrate content value of *M. nigeriensis* in this study was comparatively low to the values (43.3% and 42.8%) reported by Banjo *et al.,* (2006) for *M. bellicosus* and *M. notalensis,* respectively. However, carbohydrates are important sources of energy that serve as body fuel needed for daily activities.

The results on mineral composition showed that the values obtained for Zinc, Calcium and Iron in *Rhyncophorus phoenics and Orycetes boas* were higher than the values obtained for all other insects. The differences in mineral compositions among the insect species studied highlight the variations in their respective food sources. (Atowa *et al*., 2021). The Sodium content value obtained for *Cirina forda* is relatively high compared to the value reported by Omotoso (2006). Sodium helps in nerve function, muscle contraction, and regulation of blood pressure (Antonio *et al.,* 2023).

The result revealed that *Rhyncophorus phoenics* contained a high amount of Magnesium; the Magnesium content value obtained in *Macrotermes nigerensi*s was comparable to the value (60.69 mg) reported by Banjo *et al.,* (2006). Magnesium is an essential mineral in the diet that plays a role in nerve function, bone health, bleeding disorders, and regulates blood sugar levels (Zielinska *et al.,* 2018). The Iron content value (65.42 mg) in *Orycetes boas* was relatively higher than the value reported by Anaduaka *et al*., (2021). The high iron content in *Rhyncophorus phoenics and Orycetes boas* suggests their potential role in correcting anaemia, particularly when integrated into human diets as a sustainable source of essential micronutrients. Iron is essential for blood formation and the normal functioning of the central nervous system (Imam and Sarkingobir, 2024). The calcium content value obtained for *Apis mellifera* was similar to the value reported by Elemo *et al.,* (2011). Calcium is a vital micronutrient that supports the development of bones and teeth. It facilitates blood clotting and regulates muscle contraction (Ramesh, 2022).

CONCLUSION AND RECOMMENDATION

The findings of this study indicate that the insect species investigated constitute valuable sources of protein, carbohydrates, and essential minerals, including calcium, zinc, magnesium, and iron, which are necessary for growth, metabolic processes, and overall health. Among the species evaluated, ***Oryctes boas*** and ***Rhynchophorus phoenicis*** exhibited comparatively high mineral compositions, highlighting their potential as nutritionally valuable and sustainable alternative food sources. Consequently, these insects may be

recommended as a dietary option for addressing the widespread malnutrition prevalent among children, as they provide a sustainable, affordable, and accessible source of protein that can enhance nutritional well-being.

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