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NUTRITIONAL QUALITY OF COMMONLY CONSUMED INSECTS IN BIDA, NIGERIA

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ABSTRACT

This study investigates the nutritional composition of three edible insects commonly consumed in Bida, Niger State, Nigeria: Shea butter caterpillar (*Cirinabutyrospermi.*), locusts (*Schistocerca spp.*), and termites (*Macrotermesbellicosus*). These insects are traditionally harvested and consumed as part of local diets and offer a potentially valuable source of nutrition. Insects were purchased from local markets

Introduction

Edible insects have been an integral part of traditional diets in various parts of the world, particularly in Africa, where they serve as a vital source of nutrition and a sustainable food option (Cunha, Andrade, Ruivo and Pinto 2023; Ibitoye, Ebenebe, Oyediji & Amobi 2021). In many rural communities, including those in Nigeria, insects are valued not only for their cultural significance but also for their high nutritional content, providing essential proteins, fats, and micronutrients (FAO, 2013; Oibiokpa, Akanya, Jigam, & Saidu, 2017; Ibitoye, Ebenebe, Oyediji & Amobi 2021; Okweche, Eyo, & Effa, 2022). They are a good source of bioactive compounds and have anti-inflammatory properties, they also containunsaturated essential ω-3 and ω-6 fatty acids (Quah, Tong, Bojarska, Giller, Tan, Ziora, Esatbeyoglu, and Chai, 2023; costa-Estrada, Reyes, Rosell, Rodrigo, Ibarra-Herrera 2021).The consumption of insects, often called entomophagy, has gained global attention as a potential solution to food insecurity and environmental sustainability (Van Huis et al., 2013; Cunha, Andrade, Ruivo and Pinto 2023).

In Bida, Niger State, Nigeria, edible insects such asshea butter caterpillar (*Cirinabutyrospermi.*), locusts (Schistocerca

and processed into powder. The proximate composition, mineral content and amino acid profiles were analyzed using standard methods. The results showed that all three insect species are rich in protein, with shea butter caterpillars, locusts and termites containing approximately 58g, 43g, and 65g of protein per 100g of dry weight, respectively. They also provided significant amounts of essential amino acids, such as leucine, lysine, and valine. The insects were high in fat content, particularly termites, which contained up to 38g of fat per 100g. Additionally, these insects are rich sources of iron, zinc, and calcium, which are vital for human health, particularly in regions facing micronutrient deficiencies. They offer sustainable food alternatives that enhance dietary diversity and have the potential to mitigate malnutrition.in resource-constrained environments, exemplified by Niger State, Nigeria.

Keywords: Edible insects, sheabutter caterpillar, locusts, termites, food security, sustainable protein.

spp.), and termites (*Macrotermesbellicosus*) are commonly consumed, particularly during their peak seasons. These insects provide a cost-effective and accessible source of nutrition, especially in areas where alternative protein sources such as meat and fish are limited or expensive (Kim *et al.* 2019; Ancha, Ikyaagba, & Kaor, 2021). Local communities harvest and prepare these insects in various ways, incorporating them into their daily diets to meet their nutritional needs (Ibitoye et al 2021; Aigbedion-Ataloret *al*. 2024). Studies have shown that edible insects are rich in high-quality protein, healthy fats, and essential micronutrients such as iron, zinc, and calcium, making them an important part of traditional diets (Rumpold& Schlüter 2013; Aigbedion-Atalor *et al.* 2024; Cunhaet *al.* 2023).

The high protein, fat, and micronutrient content of sheabutter caterpilar, winged termites, and locust underscore their importance as a sustainable and nutritious food source in Bida and the broader region. In areas where conventional protein sources such as meat and fish are expensive or scarce, these insects provide an affordable and culturally accepted alternative. Their nutritional value positions them as a potential tool for addressing malnutrition and micronutrient deficiencies in Nigeria and other parts of West Africa.

Similarly, studies across West Africa have demonstrated the critical role of edible insects in traditional diets and their potential for improving food security. For instance, Niaba *et al.* (2012), Oibiokpa *et al.* (2019), Ancha *et al.* (2021) and Okweche *et al.* (2022) found that insects consumed in Côte d'Ivoire and Nigeria respectively provided essential nutrients, particularly during the lean season and among the poor households when other protein sources were unavailable or unaffordable.

The growing recognition of edible insects as a sustainable food source has led to increased research into their nutritional composition and potential role in combating malnutrition(Kim et al., 2019; Food and Agriculture Organization of the United Nations, 2013; Korean Society for Food Science of Animal Resources, 2020). Although the potential of edible insects in addressing food security has been well-documented globally, limited studies have focused on the nutritional analysis and bio-digestibility of insects consumed in specific regions of Nigeria, such as Bida. This study addresses this gap by providing a detailed nutritional analysis of commonly consumed insects and evaluating their bio-digestibility, thereby contributing to strategies for combating malnutrition.

MATERIALS AND METHODS

Study Area

The research was conducted in Bida, Niger State, Nigeria, a region known for the traditional consumption of edible insects such as Shea butter caterpillar (*Cirinabutyrospermi.)*,locusts (*Schistocerca spp.)*,termites (*Macrotermesbellicosus*). Locusts and sheabutter caterpillars are collected during the dry season, and termites are harvested after the first rains. The laboratory analysis was carried out at the International Institute of Tropical Agriculture (IITA) central laboratory, Ibadan, Oyo State and the Science Laboratory Technology (SLT) Department, Federal Polytechnic Bida, Niger State.

Raw material procurement and handling

Insects were purchased from Old Market in Bida. Extraneous particles were removed by winnowing and sorting, followed by wet-cleaning to remove adhering debris and draining and sun-drying for 72 hours.

Sample Preparation

The dried insect samples were processed by further drying to constant moisture and then reduced to a fine powder using a Kenwood stainless warring blender. The powdered samples were stored in airtight containers at room temperature until they were analyzed.

Proximate Composition Analysis

The proximate composition of the powdered samples was determined according to standard methods as outlined by AOAC (2005) Essentially, the moisture content was determined by oven-drying the samples at 105°C until a constant weight was obtained and the crude protein was measured using the Kjeldahl method. The nitrogen content of the samples was converted to protein by multiplying with a conversion factor of 6.25. The crude fat was determined using the Soxhlet method, while ash content was determined using the principle of ashing at 550°C until a constant weight was obtained, and the acid-base digestion method was employed for the crude fibre determination. The carbohydrates was calculated by difference (CbD) (AOAC 2000). Total Carbohydrate by difference (g/100g) = 100- (Protein (%) + Moisture (%) + Ash (%) + Fat (%)).

Mineral Content Analysis:

The mineral content was determined according to standard methods as outlined by AOAC (2005). The mineral content of the insect powder samples was analyzed using an atomic absorption spectrophotometer (AAS). The powdered samples were digested in a mixture of concentrated nitric acid and perchloric acid. The digest was then analyzed for iron, zinc, calcium, magnesium, and phosphorus. The AAS was calibrated with standard solutions of known mineral concentrations.

Amino Acid Profiling:

The Amino Acid profile was determined according to standard methods as outlined by AOAC (2005). Amino acid analysis was performed using high-performance liquid chromatography (HPLC), following acid hydrolysis of the insect proteins. The samples were hydrolyzed with 6N hydrochloric acid (HCl) at 110°C for 24 hours. After hydrolysis, amino acids were separated and quantified using a pre-column derivatization method with o-phthaldialdehyde (OPA) for fluorescence detection.

Bio-Digestibility Analysis

Bio-digestibility of protein was determined using an **in vitro enzymatic digestion method** (Hsu et al., 1977):

1. **Sample Preparation**: A 1 g sample of insect powder was suspended in 50 mL of phosphate buffer (pH 7.8).
2. **Enzymatic Digestion**:
   - **Pepsin Digestion**: The suspension was incubated with pepsin (pH 2.0, 37°C) for 2 hours.
   - **Pancreatin Digestion**: Following pepsin treatment, the pH was adjusted to 7.5, and pancreatin was added. The sample was incubated at 37°C for another 2 hours.
3. **Protein Hydrolysis Measurement**: The degree of protein hydrolysis was measured spectrophotometrically by analyzing free amino groups using the OPA (o-phthalaldehyde) method (Church et al., 1983). Bio-digestibility was calculated as:

The formula for calculating **protein bio-digestibility** using the **Ortho-Phthalaldehyde (OPA) method** is based on measuring the release of free amino groups during protein digestion. The OPA assay quantifies these amino groups, which correspond to protein hydrolysis.

A common formula used is:

Digestibility (%) =

(OPA value of hydrolyzed sample−OPA blank)/(OPA value of fully digested reference −OPA blank)×100

Where:

- **OPA value of hydrolyzed sample** = Absorbance reading (or fluorescence intensity) of the sample after enzymatic digestion.
- **OPA blank** = Absorbance reading of the blank solution (containing buffer and OPA reagent, without sample).
- **OPA value of fully digested reference** = Absorbance reading of a completely hydrolyzed protein reference (e.g., a known protein standard like casein or BSA).

Estimation Vitamin A Content using High-Performance Liquid Chromatography (HPLC)

AOAC Method: 974.29

Principle: Separates and quantifies retinol and provitamin A carotenoids in food samples.

Steps:

1. Extraction:
   - Saponify the sample with potassium hydroxide (KOH) in ethanol to release retinol and carotenoids.
   - Extract fat-soluble components into an organic solvent (e.g., hexane).
2. Concentration:
   - Concentrate the extract under nitrogen or vacuum.
3. Chromatographic Separation:
   - Inject the sample into an HPLC system equipped with a UV-Vis detector.
   - Retinol is typically detected at 325 nm, while carotenoids are detected at 450 nm.
4. Quantification:
   - Use calibration curves from known retinol and beta-carotene standards to calculate concentrations.
     - Expression as RE: Convert values using:
   - 1 µg retinol = 1 µg RE.
   - 6 µg beta-carotene = 1 µg RE.
   - 12 µg other provitamin A carotenoids = 1 µg RE.

Statistical Analysis

All experiments were conducted in triplicate, and data were presented as mean ± standard deviation (SD). Statistical analysis was performed using SPSS version 22. Analysis of variance (ANOVA) was used to compare means between powder samples atp < 0.05significancelevel.

RESULTS AND DISCUSSION

Nutritional composition of the edible insect

The proximate and mineral composition of the three edible insect species; Shea butter caterpillar (*Cirinabutyrospermi.*), locusts (*Schistocerca spp.),* and termites (*Macrotermesbellicosus*), is detailed in Table 1. The results revealed distinct differences and high composition of protein, fats, and essential minerals that could support their role as an important dietary resource in the region as indicated by Nowakowski, Miller, Miller, Xiao, and Wu (2022). The results are consistent with the findings of Mishyna & Glumac (2021), Ancha, *et al.* 2021; Ibitoye *et al.* 2021 and Cunha, Andrade, Ruivo and Pinto (2023) which reported that edible insects are high in protein, fat and other essential nutrients, thus highlighting their potential to address food insecurity and malnutrition due to their nutrient density.The protein content of the studied insects were notably high, with values ranging from 43.54-65.75g per 100g of dry weight across the species which is similar to the findings of Oibiokpa *et al.* (2017) and Adepoju *et al.* (2014) who reported high protein content ranging from 43.8 to 71.0 % and (36.7g/100g)respectively. Shea butter caterpillar and locusts, in particular, demonstrated protein levels comparable to those reported by Stull, Finer, Bergmans, Febvre, Longhurst, Manter, Patz, & Weir (2019). Similarly, Banjo *et al.* (2006) and Aigbedion-Atalor, *et al.* (2024) found that locusts, shear butter caterpillar and termites which are commonly consumed in Nigeria contained between 50-65g of protein per 100g of dry weight, similar to the values found in this study. Winged termites also presented significant protein levels, aligning with reports of 38-45g/100g crude protein for winged termites in Nigeria (Fasoranti and Ajiboye 1993; Aigbedion-Atalor, *et al*. 2024).These findings suggest that edible insects can serve as a viable alternative to conventional animal proteins, especially in regions where access to meat and fish is limited.

Table 1: Proximate and Mineral Composition of Edible Insects

g/100g	SBC	WT	Lc
Crude protein	54.92±0.13	46.54±0.09	63.85±0.46
Crude fat	20.67±0.71	37.86±1.00	16.90±0.40
Ash	3.21±0.09	2.82±0.14	2.70±0.05
Carbohydrates	12.09±0.5	4.10±1.6	7.76±0.65
Fibre	4.53±0.09	4.28±0.28	4.24±0.06
Moisture	4.50±0.5	4.35±0.5	4.45±0.4
Mineral Composition (mg/100g)			
Iron	40	20	11
Zinc	11	8.8	6.8
Calcium	48	40	30
Magnesium	50	60	45
Phosphorus	110	100	95

SBC=Sheabutter caterpillar powder
WT=Winged termite powder
Lc=Locust powder

The fat content in the insects studied was particularly high in winged termites, with levels reaching 37.86g per 100g making them an excellent source of energy and unsaturated fatty acid. This is consistent with studies conducted by Ayieko et al. (2012), who reported similarly high fat levels (14.3- 30.4%) in termites consumed in Kenya and across West Africa. Termites are known to have high levels of polyunsaturated fats, which are beneficial for heart health, making them a valuable food source in regions where dietary fats are lacking. Locusts contained moderate amounts of fat (16.90±0.40 g/ 100g) primarily composed of unsaturated fatty acids. These findings are in line with research conducted by Rumpold and Schlüter (2013)which ranged between 10-30 g/ 100g. However, Rumpold and Schlüter (2013) and da Silva Lucas, de Oliveira, da Rocha, & Prentice (2019) emphasized on the beneficial fat composition of edible insects since they contain more unsaturated fatty acids than other animal sources. The moderate fat content, coupled with their high protein value, makes locusts and crickets nutritionally well-balanced and ideal for addressing both energy and protein deficiencies. Compared to beef and pork, insects have been reported to be rich in unsaturated fatty acid, which is about 75% of total fatty acid content. The fibre and carbohydrate contents ranged from (3.24 – 5.53 and 5.16-11.67) respectively in the selected insects which is consistent with the findings of Okweche *et al.* (2022) who reported that crickets contain a significantly higher level of crude fiber which is significant compared to conventional Nigerian meat sources, such as fish, chicken, beef, and goat (Lange & Nakamura, 2023). Similarly, Aigbedion-Atalor *et al.* (2024) showed a similar trend in the fibre and carbohydrate content of crickets (15 g/100g and 15.1g/100g respectively) while the fibre content of winged termites was 5.5g/100g.Edible insects are also an important source of dietary fibre, since the exoskeleton of many insects consists of chitin (Lange & Nakamura, 2023). The proximate content of these selected insects indicated that they could contribute to the realization of the first three UN SDGs -zero poverty, zero hunger, and good health and well-being. Hence, Edible insects are good source of food bioactives, such as minerals, polyunsaturated fatty acids and fibre, and may be able to provide a wide range of food supplements and functional food (Lange & Nakamura, 2023).

The mineral analysis showed that the studied insects are rich in essential minerals such asiron, zinc, and calcium, which are often lacking in many rural diets in Nigeria and West Africa. Iron content was particularly high in sheabutter caterpillar and winged termites, ranging from 20-40 mg per 100g, which is consistent with values reported by Omotoso (2006) (18.9-22.5 mg/100g) which is higher higher than the values

obtained in beef, chicken and fish (Adepoju & Omotayo 2014; Lange & Nakamura, 2023). However, Adepoju & Omotayo (2014) in similar study on the nutritional composition of termites in southwestern Nigeria reported a lower range (0.84-1.42 mg/100g). The high levels of iron are critical for preventing anemia, especially in women and children, who are often at risk of iron deficiency in these regions. since it is above the recommended dietary allowance (RDA) for women and children (8-27mg/day) for both adults and children (National Academies of Science 2019). Similarly, the zinc content ranged between 6.8 – 11 mg with shea butter caterpillar having the highest and locust the lowest, these values are within the RDA (3-14 mg/day) (National Academies of Science 2001). The mineral content in the selected insects could help in reinforcing their role in supporting immune function and overall health. For example, zinc is essential for growth, cell replication, fertility and reproduction, and hormonal activities. Zinc deficiency is a common issue in sub-Saharan Africa, and the inclusion of these insects in the diet could help mitigate this problem, as suggested by Womeni *et al.* (2009) and Adepoju *et al.,* (2014) in Cameroon and Nigeria respectively, who found comparable levels of zinc in local edible insects. Similary studies by Oibiokpa *et al.* (2017); Ibitoye *et al.* (2021); Okweche *et al.* (2022) and Aigbedion-Atalor *et al.* (2024) also corroborated the high mineral content present in edible insects and their potential in solving micronutrient deficiency in Africa.
Calcium levels in the study were also noteworthy, ranging from 30-48 mg per 100g, making these insects valuable for bone health. This finding is consistent with that of Bukkens (2005); Oibiokpa *et al.* (2017)and Aigbedion-Atalor *et al.* (2024) who reported high calcium levels in winged termites compared to chicken, pork, and beef.

Amino acid profile of the Edible Insects

The amino acid profile of the edible insects consumed in Bida is as illustrated in Table 2.

Table 2: Amino acid profile of the edible Insects

EAA (mg/100g dry weight)	SBS	WT	Lc
Leucine	7.2	6.6	6.9
Isoleucine	4.5	4.3	4.6
Lysine	5.8	5.3	6.1
Methionine	1.4	1.5	1.3
Phenylalanine	4.6	4.3	4.1
Threonine	4	3.4	3.3
Tryptophan	1	1.4	1.2
Valine	4.7	4.4	4.2
Histidine	2	1.3	1.6
TEAA	**38.2**	**32.5**	**33.3**

EAA (mg/100g dry weight)	SBS	WT	Lc
NEAA			
Alanine	4.8	4.5	4.7
Arginine	6.3	5.6	5.2
Aspartic acid	8.8	7.3	8.2
Glutamic acid	11.8	11.2	11.5
Glutamine	5.7	4.5	5.2
Proline	4.2	3.5	3.8
Serine	4.3	3.9	3.9
Tyrosine	2.9	2.7	2.8
TNEAA	**48.8**	**43.2**	**45.3**

EAA=Essential amino acids, NEAA=Non Essential amino acids, TEAA=TotalEssential amino acids, TNEAA= Total Non-Essential amino acids, SBC=Sheabutter caterpillar powder
WT=Winged termite powder
Lc=Locust powder

The presence of essential amino acids further underscores the suitability of these insects as a protein source. This is in tandem with the study on the amino acid profiles of edible insects in West Africa (Ekpo & Onigbinde, 2007; Oibiokpa *et al.* 2017; Stull *et al.* 2019). Similarly, Okweche *et al.* (2022) and Adepoju *et al.* (2014) reported that African crickets and termites are rich in essential amino acids.Edible insects contains all essential amino acids necessary for human growth and maintenance and is considered to be of high quality compared to animal sources (Oibiokpa *et al.* 2017; Stull *et al.* 2019; Ibitoye *et al.* 2021; Okweche *et al.* 2022; Cunha *et al.* 2023; Lange & Nakamura, 2023).

Table 3: Bio-Digestibility (%) of Edible Insects (dry weight)

	SBC	WT	Lc
Biodigestibility	80.425	88	85.365

SWC….shearbutter catterpillar
WT……winged termite
Lc……..locust

Bio-digestibility, which measures how well a food's nutrients are absorbed by the body, is an essential factor in evaluating the nutritional quality of edible insects. Protein digestibility of insects like locusts and termites ranges from 80% to 95%, comparable to that of soybeans and eggs (Hsu *et al.*, 1977; Bukkens, 1997). However, digestibility can be affected by the presence of chitin, the indigestible fiber in insect exoskeletons, which may reduce nutrient availability if not properly processed (Fombong *et al.*, 2017).

Table 4: Vitamin A Content of Edible Insects (ug/g dry weight)

	SBC	WT	Lc
RE	35.832	26.445	11.263

CONCLUSION

In conclusion, this study reaffirms the significant nutritional contributions of sheabutter caterpillar, winged termites, and locusts consumed in Bida, Niger State, Nigeria. These insects' high protein, fat, and mineral content make them a valuable addition to local diets and a promising solution to addressing nutritional challenges in the region. The study further highlights the role of edible insects in enhancing food security and improving dietary diversity. Given the increasing global demand for sustainable food sources, promoting the consumption of edible insects could play a crucial role in achieving food security in Nigeria and beyond.

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