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# Proximate and Mineral Composition of *Macrotermes nigeriensis* and its Potential for Food Fortification

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## Abstract

This study evaluated the proximate and mineral composition of *Macrotermes nigeriensis*, an edible termite species, to assess its potential for food fortification. Adult winged termites were collected, oven-dried, and analyzed using standard AOAC methods. The analysis revealed high fat (37.33 ± 4.93%) and moderate protein (15.59 ± 1.15%) and carbohydrate (17.84 ± 5.81%) content, yielding a calculated energy value of 466.57 kcal/100g. Mineral analysis showed significant levels of sodium (21.80 mg/g) and magnesium (10.60 mg/g). The low moisture content (5.07 ± 0.90%) enhances shelf stability. Compared to other Macrotermes species, M. nigeriensis presents a compelling nutritional profile, particularly as a high-energy lipid source. The findings strongly support its integration into food security strategies to combat protein-energy malnutrition and micronutrient deficiencies in sub-Saharan Africa. Further research on nutrient bioavailability and consumer acceptance is recommended.

**Keywords:** *Macrotermes nigeriensis*; Edible Insects; Food Security; Proximate Analysis; Mineral Analysis; Nigeria

## 1. Introduction

*Macrotermes nigeriensis* is a widely consumed edible termite species in Nigeria, where it is locally known as Aku (Igbo), Esusu (Yoruba), and Chinge (Hausa) (Igwe et al., 2011). This insect, particularly in its winged alate form, is traditionally harvested at the onset of the rainy season and is relished as a delicacy across various Nigerian communities due to its nutty flavor and rich oil content (Ayotunde-Ojo & Omoyeni, 2024; Cheseto et al., 2024).

With the increasing burden of food insecurity, hunger, and protein-energy malnutrition (PEM), especially among children and women in sub-Saharan Africa, alternative food sources are urgently needed (Aigbedion-Atalor et al., 2024; Hlongwane et al., 2020). The worsening food crisis, exacerbated by rapid population growth, climate variability, and economic challenges, has prompted renewed interest in the nutritional exploitation of edible insects, which are often more accessible and affordable than conventional animal protein sources (Babirye et al., 2024; Makore et al., 2025).

Insects such as *Macrotermes nigeriensis* have been shown to be highly nutritious, containing significant levels of protein, fats, and essential micronutrients such as iron and zinc. They can provide dietary benefits comparable to those of meat and fish (Adepoju & Omotayo, 2014; Cheseto et al., 2024). Moreover, studies have demonstrated their potential to contribute substantially to Recommended Dietary Allowances (RDAs), thereby playing a critical role in combatting micronutrient deficiencies and supporting public health, particularly in nutritionally vulnerable groups such as children (Anyiam et al., 2022a; Anyiam et al., 2022b).

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Despite the longstanding cultural acceptance and ecological availability of termites in Nigeria, comprehensive and recent scientific investigations into their nutritional and mineral compositions using standardized methods remain limited. This study, therefore, aims to bridge this gap by evaluating the proximate and mineral composition of *Macrotermes nigeriensis* using standard AOAC (2016) procedures, with a view to promoting its inclusion in strategies for sustainable food security and nutritional improvement.

## 2. Methodology

### 2.1. Sample Collection and Preparation

Adult winged *Macrotermes nigeriensis* termites were collected during their swarming period in April-May 2023 from the campus of Federal Polytechnic Nekede, Owerri, Imo State, Nigeria (Latitude 5.4546° N, Longitude 7.0356° E). Collection was performed using manual methods and light traps placed under illuminated areas during dusk and early night. The collected samples were thoroughly washed with distilled water to remove debris and oven-dried at 60°C for 12 hours until constant weight was achieved. Dried termites were milled into a fine powder using a clean laboratory grinder and stored in airtight containers at room temperature until analysis.

### 2.2. Proximate Composition Analysis

Proximate analyses (moisture, crude fat, crude protein, ash, crude fiber, and carbohydrate) were conducted following standard procedures outlined in the *Official Methods of Analysis* of the Association of Official Analytical Chemists (AOAC International, 2016).

- Moisture Content: Determined by drying approximately 2 g of sample at 105°C to constant weight.
- Crude Fat: Extracted with petroleum ether using a Soxhlet apparatus.
- Crude Protein: Measured using the Kjeldahl method and converted by multiplying the nitrogen content by 6.25.
- Ash Content: Determined by incinerating samples in a muffle furnace at 550°C for 4 hours.
- Crude Fiber: Analyzed through sequential acid and alkaline digestion.

Carbohydrate Content was calculated by difference:

% Carbohydrate = 100 − (% moisture + % protein + % fat + % ash + % fiber).

Each analysis was performed in triplicate, and results were expressed as mean ± standard deviation.

### 2.3. Mineral Composition Analysis

Minerals including sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), and iron (Fe) were determined using atomic absorption spectrophotometry (AAS) (PinAAcle 900T, PerkinElmer, USA). Approximately 0.5 g of the powdered sample was digested using a mixture of nitric acid and perchloric acid (3:1 v/v), filtered, and diluted to 50 mL with deionized water. The concentrations of elements were measured against calibration curves prepared from certified standard solutions. Analytical quality assurance was performed using a standard reference material (NIST 1547 Peach Leaves).

## 3. Results

### 3.1. Proximate Composition

The results of the proximate analysis of *Macrotermes nigeriensis* are presented in Table 1. The termite samples showed substantial levels of fats, followed by carbohydrate and protein. Moisture content was relatively low, while crude fiber and ash contents were moderate.

**Table 1** Proximate Composition of *Macrotermes nigeriensis* (on dry weight basis)

| Parameter | Mean Result (%) |
|---|---|
| Moisture | 5.07 ± 0.90 |
| Fats | 37.33 ± 4.93 |

| | |
|---|---|
| Crude Fiber | 13.67 ± 1.53 |
| Ash | 10.50 ± 1.80 |
| Protein | 15.59 ± 1.15 |
| Carbohydrate | 17.84 ± 5.81 |

Values are mean ± standard deviation of triplicate determinations.

The calculated energy value, based on the proximate composition, was 466.57 kcal per 100g of dried sample.

### 3.2. Mineral Composition

The mineral profile of *Macrotermes nigeriensis* is presented in Table 2. Sodium was the most abundant mineral, followed by magnesium. Other essential minerals including calcium, potassium, and iron were also detected.

**Table 2** Mineral Composition of *Macrotermes nigeriensis* (mg/g, dry weight)

| **Parameter** | **Content (mg/g)** |
|---|---|
| Potassium (K) | 0.36 |
| Magnesium (Mg) | 10.60 |
| Sodium (Na) | 21.80 |
| Calcium (Ca) | 1.33 |
| Iron (Fe) | 0.32 |

## 4. Discussion

The high fat content (37.33%) observed in this study aligns with values characteristic of the Macrotermes genus (Cheseto et al., 2024; Makore et al., 2025). This substantial lipid component is significant, as it contributes to the desirable sensory properties and high energy density of the insect. The calculated energy value of 466.57 kcal/100g underscores the potential of M. nigeriensis as a high-energy food source, which is crucial for addressing calorie deficits in vulnerable populations.

The crude protein level of 15.59% establishes M. nigeriensis as a moderate but valuable protein source. This value is lower than the 36.7% reported for M. bellicosus by Adepoju & Omotayo (2014), a variation that may be attributed to interspecies differences, diet, or the developmental stage of the insects at collection. Nonetheless, even at this level, a modest serving can meaningfully contribute to daily protein intake, which is critical for growth, immune function, and cognitive development, particularly in children.

The low moisture content (5.07%) is a favorable attribute that enhances the shelf-life and stability of the dried product by minimizing risks of microbial spoilage. The appreciable crude fiber (13.67%) may offer benefits for digestive health, while the ash content (10.50%) indicates a rich repository of essential minerals.

The mineral profile revealed remarkably high levels of sodium (21.80 mg/g) and magnesium (10.60 mg/g). These electrolytes are essential for numerous physiological processes, including nerve transmission, muscle contraction, and maintaining fluid balance. The detected levels of calcium (1.33 mg/g) and iron (0.32 mg/g), while lower than those reported in some other termite species (Cheseto et al., 2024), still represent a valuable dietary source. For instance, the iron content can contribute to the prevention of iron-deficiency anemia, a prevalent public health issue in the region.

When compared to the literature, the nutritional profile of M. nigeriensis shows both consistencies and variations. The fat content is congruent with findings by Cheseto et al. (2024), while the protein content is more moderate. These discrepancies highlight the influence of species, geography, and analytical methods on final composition.

A key consideration not addressed in this study is the bioavailability of the detected nutrients, which is a critical factor for determining their true nutritional impact. Furthermore, the sample represents a single location and season; thus, the generalizability of the findings may be influenced by environmental and seasonal factors.

## 5. Conclusion

The present study provides a comprehensive evaluation of the proximate and mineral composition of *Macrotermes nigeriensis*. The results confirm that this termite species is a nutritionally valuable food source, characterized by high fat content (37.33%), moderate protein (15.59%) and carbohydrate (17.84%) levels, and a substantial energy value of 466.57 kcal/100g. The mineral profile is particularly notable for its high concentrations of sodium (21.80 mg/g) and magnesium (10.60 mg/g), along with detectable levels of calcium (1.33 mg/g) and iron (0.32 mg/g).

These findings align with previous research on Macrotermes species while highlighting the specific nutritional signature of M. nigeriensis. The high fat and energy content, coupled with appreciable protein and mineral levels, substantiate its potential as a supplementary or alternative food source to combat protein-energy malnutrition and micronutrient deficiencies. The low moisture content further enhances its storage potential for food security applications. Evidence from prior studies supports the strategic inclusion of M. nigeriensis in food fortification efforts aimed at improving dietary quality. This study reinforces the importance of edible insects as sustainable, nutrient-dense foods worthy of inclusion in food security strategies.

### *Recommendations*

While this study establishes the nutrient content, it is recommended that subsequent research investigate the bioavailability of the minerals present, particularly iron and zinc. Furthermore, studies on potential anti-nutritional factors and the impact of different processing methods on nutrient retention are necessary to ensure safety and efficacy.

## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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