ISSN:
Print - 2277 - 0755
Online - 2315 - 7453

Journal of Agricultural Science and Environment

INTRA-SPECIFIC VARIATION OF NUTRITIONAL COMPOSITION OF EDIBLE TERMITES AT THE FEDERAL UNIVERSITY OF AGRICULTURE, ABEOKUTA, NIGERIA

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ABSTRACT

Edible insects, particularly termites, have gained increasing attention as alternative protein sources due to their high nutritional value and sustainability potential. This study aimed to determine the proximate and mineral compositions of termite castes from the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. Samples collected from five termitaria, were roasted and ground into a fine powder for analyses. Moisture, dry matter, crude protein, crude fat, ash, crude fiber and carbohydrate contents were determined. Magnesium, phosphorus, iron, zinc and selenium were assessed using atomic absorption spectrophotometry (AAS) and the Vanadomolybdate colorimetric method for phosphorus determination. Relationships among proximate and mineral components were determined. Moisture content varied significantly across termite castes, with the Queen exhibiting the highest moisture content (90.53 ± 1.11 g/100 g) and the King the lowest (86.38 ± 0.63 g/100 g). Crude protein content was highest in the Queen (7.78 ± 0.85 g/100 g) and lowest in the Worker (3.15 ± 0.98 g/100 g); fat content was higher in the Queen (1.42 ± 0.72 g/100 g) compared to other castes. Magnesium levels were highest in the Soldier caste (11.49 ± 0.79 mg/100 g), while selenium content was highest in the King caste (28.39 ± 0.82 µg/100 g). Calcium, magnesium and phosphorus exhibited strong positive correlations ($p < 0.01$) but zinc demonstrated a negative correlation with calcium ($r = -0.62$, $p < 0.05$) and magnesium ($r = -0.64$, $p < 0.05$). Iron and selenium did not show significant correlations with other minerals, implying independent metabolic regulation. Termites, particularly the reproductive castes, are rich sources of essential macronutrients, including protein, fat, and carbohydrates, underscoring their potential as a highly nutritious food source.

Keywords*:* Termite; Nutrition; Proximate Composition; Minerals

INTRODUCTION

Imagine a world where some of the smallest creatures play a crucial role in maintaining ecosystems and ensuring food security. Termites, often seen as mere pests, are actually nature's engineers helping to break down organic matter, improve soil health and even providing a rich source of nutrition for humans. Found in forests, woodlands, grasslands and agricultural fields, these social insects carve out niches in soil, dead wood and leaf litter, playing a vital role in nutrient cycling and ecosystem health. Termites are fascinating social insects that live in highly organized colonies with a strict caste system (Orkin, 2023; Krishna, 2023). Each caste, defined by morphology and function, plays a crucial role in the colony's survival and success. Termites, widely consumed in developing countries like Nigeria and China, are a valuable food source due to their high nutritional value and potential for sustainable production. Yet, their biochemical and proximate compositions remain largely unexplored, hindering a full understanding of their nutritional potential. Recent studies have shed light on the valuable nutrients found in termites. Kinyuru *et al.* (2013) analyzed four termite species in Kenya, revealing their richness in protein, fat and minerals. These findings are supported by research highlighting the superior nutrient content of insects compared to traditional protein sources like beef and fish. Adepoju (2020) emphasized that insects often contain more protein, fat and carbohydrates than equal amounts of other animal products, with higher energy value than even soybeans and maize. Also, edible insect caterpillars offer comparable levels of protein, fat, vitamins, minerals and calories to meat, milk and eggs while boasting significantly higher levels of protein and fat than their plant-based food sources. Beyond their nutritional value, termites hold promise as a source of bioactive compounds with potential health benefits. Hammoud *et al.* (2021) identified bioactive compounds in various termite species, suggesting their potential role in traditional medicine. Their research supports the antibacterial properties of *Macrotermes bellicosus*, further strengthening its previously established anti-inflammatory effects. Similarly, Paloi *et al.* (2023) explored bioactive compounds in termites, demonstrating their potential to combat various diseases like cancer, hyperlipidemia and Alzheimer's. Additionally, these compounds possess valuable antioxidant and antimicrobial properties. Their significant protein content, often exceeding that of traditional sources like beef and fish, makes them a valuable dietary addition. Mahapatro (2015) and Adepoju (2020) confirm the high protein content of termites, highlighting their abundance of essential amino acids like lysine, threonine and methionine. Beyond protein, termites offer a wealth of vital minerals like calcium, iron and zinc, which are essential for human health (Kinyuru *et al.,* 2013). Their potential for sustainable production and their ability to provide a livelihood for communities through collection and sale further strengthen their appeal as a sustainable food source. This study aimed to contribute to the knowledge of the intra specific nutritional value of termite castes delving into their proximate and mineral compositions. This study is novel because it provides a comparative intra-specific evaluation of the proximate and mineral compositions of four permanent termite castes (King, Queen, Soldier, and Worker) rather than treating termites as a single pooled food source. This work uniquely reports selenium (Se) content and examines correlation relationships among proximate and mineral components across castes. This study also generates baseline nutritional data for edible termites collected from the Federal University of Agriculture, Abeokuta (FUNAAB), Nigeria, a location for which such information has not previously been documented. This research holds significant potential for promoting the consumption of termites as a viable and sustainable solution to global food security and nutritional needs.

MATERIALS AND METHODS

Study Area

The study was carried out at the Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria (latitude 7°13' N; longitude 3°26' E) - Figure 1. FUNAAB is a specialized institution covering approximately 10,000 hectares in the north-eastern region of Abeokuta. The University is situated adjacent to the Ogun-Osun River Basin Development Authority (OORBDA) along the Osiele-Abeokuta Road, off the Abeokuta-Ibadan Road (Ufoegbune and Fabiyi, 2016). FUNAAB is positioned within the humid lowland rainforest region, characterized by two distinct seasons: a wet season from March to October and a dry season from November to February (Ufoegbune and Fabiyi, 2016). The University is located in Abeokuta, the capital of Ogun State in southwestern Nigeria. Abeokuta, situated on the east bank of the Ogun River amid a landscape of rocky outcrops and wooded savanna, lies approximately 77 kilometers north of Lagos by railway and 130 kilometers by water (Wikipedia, 2023).

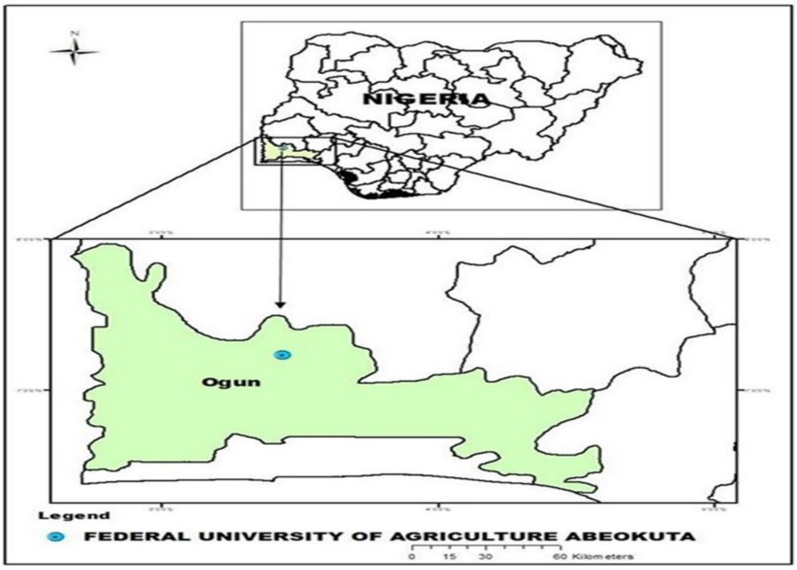

Figure 1: Map showing the location of Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria.
Source: Adenubi *et al.*, 2021

Sample Collection

Termite samples were collected from five independent termitaria located within the University premises. Selection criteria for the termitaria included structural integrity, evidence of high activity (fresh soil deposits) and proximity to undisturbed vegetation (Plate 1). Sampling followed recent recommended field protocols for termite collections and mound selection (Davies *et al.,* 2021) and considered mound architecture and microclimatic stability when choosing colonies (Vesala *et al.,* 2019). Collections were carried out early in the morning and transported promptly to the laboratory to minimize stress and preserve physiological integrity, consistent with field best practice for preserving termite physiology (Woon *et al.,* 2019).

Plate 1: Image of one of the Termitaria from which the termites' castes were collected
Source: Field Survey, 2023.

Plate 2: Image of the Queen termite after collection
Source: Field Survey, 2023

Identification and Categorization of Termite Castes

Termites were manually extracted by carefully breaking open the termitaria. The collected individuals were sorted into four castes: workers, soldiers, queens, and kings (Plate 2). The specimens were immediately transferred into well-ventilated plastic containers containing moist soil to maintain optimal humidity during transportation to the laboratory. To prevent desiccation and physiological deterioration, all samples were processed within one hour of collection. Morphological identification of termite castes was performed using a magnifying lens and standard taxonomic keys following established procedures for termite taxonomy (Eggleton, 2010; Krishna *et al.,* 2013).

Winged termites (Alates) were excluded

from this study because the objective was to assess intra-specific nutritional variation among the permanent colony castes (King, Queen, Worker, and Soldier). Winged termites are seasonal reproductive forms that appear only during nuptial flights and are not continuously present within established colonies. Their transient physiological condition and high lipid accumulation prior to flight could introduce bias when comparing stable caste-based nutritional composition. Therefore, only permanent castes were selected to ensure consistency and reliability of nutritional comparisons.

Sample Preparation and Processing

In the laboratory, each caste sample (workers, soldiers, queens, and kings) was handled separately. Foreign matters were first removed manually, after which the body weight of each caste obtained from each termitarium was recorded using a sensitive weighing scale. Each caste sample was then thoroughly washed under running distilled water to eliminate surface contaminants. The washed samples were roasted at 150°C for 10 minutes to reduce moisture content and preserve bioactive components. The dried termites were ground into a fine powder using a blender and transferred into clean 500-mL reagent bottles. The powdered samples were stored at room temperature in a dark environment until analysis. All proximate and mineral analyses were conducted following the standard procedures of the Association of Official Analytical Chemists (AOAC, 2019).

Proximate Analysis

a) Protein Determination

Crude protein content was analyzed using the Kjeldahl method following AOAC (2019). A 0.5 g homogenized sample was weighed into a Kjeldahl digestion flask and treated with 10 mL of concentrated H_2SO_4, followed by the addition of a Kjeldahl catalyst tablet (containing $CuSO_4$ and K_2SO_4) to accelerate digestion. The mixture was digested on a heating block at 420°C for 90–120 minutes until the solution became clear.

After cooling, the digest was diluted with distilled water and transferred into the distillation unit. A 40% NaOH solution was added to liberate ammonia, which was distilled into 25 mL of 2% boric acid solution containing mixed indicator. The distillation process lasted 10–15 minutes.

The trapped ammonia was titrated using 0.1 N HCl and nitrogen content was calculated. Crude protein was obtained by multiplying %N by 6.25, the standard conversion factor for insect and food samples (Jiang *et al.,* 2014).

b) Lipid Determination

Crude lipid content was measured using the Soxhlet extraction method (Mussatto, 2015). Approximately 2 g of dried powdered sample was placed into a fat-free cellulose extraction thimble and lightly sealed with cotton wool. The thimble was inserted into a Soxhlet extractor connected to a round-bottom flask containing 150 mL of petroleum ether (40–60°C). Lipid extraction was carried out for 6 hours under continuous reflux. After extraction, the solvent was evaporated and the residual lipid was dried in an oven at 105°C for 30 minutes and weighed. Lipid content was expressed as g/100 g dry matter.

c) Crude Fibre Determination

Crude fibre was determined according to AOAC procedures (AOAC, 2019). About 1 g of dried powdered sample was boiled in 200 mL of 1.25% sulfuric acid for 30 minutes to remove soluble carbohydrates. The residue was filtered and then boiled in 200 mL of 1.25% sodium hydroxide for another 30 minutes to remove remaining soluble components. The residue was filtered, dried at 105°C for 2 hours, and weighed. It was then ashed in a muffle furnace at 550°C for 4 hours, and the weight difference before and after ashing was recorded as crude fibre (g/100 g dry matter).

d) Ash Determination

Crude ash content was determined by incinerating approximately 2 g of dried powdered sample in a pre-weighed porcelain crucible in a muffle furnace at 550°C for 6 hours until a constant weight was obtained. The crucible was cooled in a desiccator, and the residue was weighed. Ash content was expressed as g/100 g dry matter (AOAC, 2019).

e) Carbohydrate Determination

Carbohydrate content was estimated using the difference method:

$$\text{Carbohydrate (\%)} = 100 - (\text{Protein} + \text{Fat} + \text{Crude Fiber} + \text{Ash})$$

Values were expressed on a dry matter basis.

Mineral Analysis

Mineral composition of the samples was determined following standard wet-ash digestion and spectrophotometric procedures described by AOAC (2019). A 1.0 g of each finely ground sample was weighed into a porcelain crucible and incinerated in a muffle furnace at 550°C for 6 hours. After cooling, the ash was dissolved in 10 mL of 3 M hydrochloric acid (HCl) and heated gently on a hot plate for 10 minutes to ensure complete dissolution of mineral residues. The digest was then filtered into a 50 mL volumetric flask and made up to volume with deionized water, and this solution served as the stock digest for all subsequent mineral determinations.

Phosphorus concentration was determined using the vanadomolybdate yellow colorimetric method, which is widely employed due to its sensitivity, colour stability, and high reproducibility (AOAC, 2019). A 5 mL aliquot of the digested sample was transferred into a test tube and reacted with 10 mL of ammonium vanadomolybdate reagent, prepared from ammonium molybdate and ammonium metavanadate in a nitric acid medium. The mixture was thoroughly shaken and allowed to stand for 10 minutes for full colour development. Absorbance was measured at 430 nm using a UV–Visible spectrophotometer, and phosphorus concentration was computed by comparison with a calibration curve prepared from KH_2PO_4 standards ranging from 0 to 10 mg/L.

The concentrations of calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn), manganese (Mn), and selenium (Se) were determined using Atomic Absorption Spectrophotometry (AAS) following AOAC (2019) procedures. A 5 mL aliquot of the digested mineral extract was aspirated into an AAS instrument equipped with an air–acetylene flame and element-specific hollow cathode lamps. Wavelengths were set according to standard analytical protocols: 422.7 nm for Ca, 285.2 nm for Mg, 248.3 nm for Fe, 213.9 nm for Zn, 279.5 nm for Mn, and 196.0 nm for Se. Calibration curves were prepared using certified reference standards diluted to 0.5–10 mg/L, and each sample was analysed in triplicate. Mineral concentrations were calculated by interpolating sample absorbance values from the corresponding standard curves.

Data Analysis

All data are presented as mean ± standard deviation (n = 3 per termite caste). Differences in proximate and mineral compositions among termite castes were evaluated using one-way analysis of variance (ANOVA). Where significant differences were detected, means were separated using Tukey's Honestly Significant Difference (HSD) post hoc test at $p < 0.05$.

Pearson's correlation analysis was used to determine the relationships among proximate composition parameters and among mineral elements. Correlation coefficients were interpreted based on their strength and direction, with statistical significance determined at $p < 0.05$ and $p < 0.01$ levels. All statistical analyses were performed using IBM SPSS Statistics version 21.

RESULTS

Proximate Composition of Different Termite Castes

Proximate composition varied across termite castes, with significant differences observed in several parameters (Table 1). Moisture content (MC) was highest in the queen (90.53 ± 1.11 g/100 g), which differed significantly from the king (86.38 ± 0.63 g/100 g), while soldiers and workers showed intermediate values without significant differences from either group. Dry matter content (DMC) followed an inverse trend, with the king exhibiting the highest value (13.29 ± 0.99 g/100 g), significantly higher than the queen (9.31 ± 0.74 g/100 g), whereas soldiers and workers showed no significant differences between them.

Fat content (FC), ash content (AC), and crude fibre content (CFC) did not differ significantly among the termite castes, indicating relatively uniform distribution of these components. Crude protein content (CPC) was comparable among the king (7.09 ± 0.81 g/100 g), queen (7.78 ± 0.85 g/100 g) and soldier (6.46 ± 0.97 g/100 g), but was significantly lower in the worker caste (3.15 ± 0.98 g/100 g). In contrast, carbohydrate content (CC) was highest in workers (7.11 ± 1.12 g/100 g), significantly exceeding values recorded in the queen (3.50 ± 0.14 g/100 g) and soldier (4.12 ± 1.05 g/100 g), while the king showed intermediate values (Table 1).

Table 1: Proximate Composition of Termite Castes (g/100 g Sample)

Treatment	King (Mean ± SD)	Queen (Mean ± SD)	Soldier (Mean ± SD)	Worker (Mean ± SD)
MC	86.38 ± 0.63^{b}	90.53 ± 1.11^{a}	88.30 ± 0.76^{ab}	88.21 ± 1.32^{ab}
DMC	13.29 ± 0.99^{a}	9.31 ± 0.74^{b}	11.77 ± 0.82^{ab}	11.26 ± 0.92^{ab}
FC	0.47 ± 0.42^{a}	1.42 ± 0.72^{a}	0.56 ± 0.33^{a}	0.58 ± 0.47^{a}
AC	0.72 ± 0.70^{a}	0.36 ± 0.61^{a}	0.72 ± 0.40^{a}	0.42 ± 0.19^{a}
CFC	0.47 ± 0.92^{a}	0.20 ± 0.01^{a}	0.00 ± 0.52^{a}	0.39 ± 0.53^{a}
CPC	7.09 ± 0.81^{a}	7.78 ± 0.85^{a}	6.46 ± 0.97^{a}	3.15 ± 0.98^{b}
CC	4.85 ± 0.84^{ab}	3.50 ± 0.14^{b}	4.12 ± 1.05^{b}	7.11 ± 1.12^{a}

Note: Values represent mean ± standard deviation (n = 3 per caste). Means within the same row with different superscript letters are significantly different at $p < 0.05$ based on one-way ANOVA followed by Tukey's HSD test. MC = Moisture Content; DMC = Dry Matter Content; FC = Fat Content; AC = Ash Content; CFC = Crude Fibre Content; CPC = Crude Protein Content; CC = Carbohydrate Content

Mineral Composition of Termite Castes

The mineral composition of termite castes showed variation across elements, with statistically significant differences observed only for magnesium (Mg) and selenium (Se), while other minerals remained relatively uniform among castes (Table 2). Calcium (Ca) content ranged from 6.12 ± 1.11 mg/100 g in workers to 8.56 ± 0.83 mg/100 g in kings; however, these differences were comparable. Phosphorus (P) values varied slightly among castes, with the highest concentration recorded in soldiers (8.19 ± 0.65 mg/100 g) and the lowest in workers (5.19 ± 1.11 mg/100 g), but no significant differences were detected. Iron (Fe) and zinc (Zn) also showed no significant variation, despite observable numerical differences, with workers exhibiting the highest Fe concentration (5.36 ± 1.03 mg/100 g) and queens showing the highest Zn level (2.53 ± 0.77 mg/100 g).

In contrast, magnesium (Mg) content differed significantly among castes. Soldiers (11.49 ± 0.79 mg/100 g) and kings (10.29 ± 0.68 mg/100 g) had significantly higher Mg concentrations compared to queens (5.31 ± 0.72 mg/100 g) and workers (4.45 ± 0.70 mg/100 g), which did not differ significantly from each other. Selenium (Se) also showed marked and significant variation, with the highest concentration observed in kings (28.39 ± 0.82 μg/100 g), followed by queens (19.85 ± 1.23 μg/100 g), while workers (10.15 ± 1.10 μg/100 g) and soldiers (6.87 ± 1.22 μg/100 g) had significantly lower values, each differing from one another.

Table 2: Mineral Composition of Termite Castes (per 100 g Sample)

Treatment	King (Mean ± SD)	Queen (Mean ± SD)	Soldier (Mean ± SD)	Worker (Mean ± SD)
Ca (mg/100 g)	8.56 ± 0.83^a	7.13 ± 0.97^a	8.13 ± 1.18^a	6.12 ± 1.11^a
Mg (mg/100 g)	10.29 ± 0.68^a	5.31 ± 0.72^b	11.49 ± 0.79^a	4.45 ± 0.70^b
P (mg/100 g)	7.67 ± 0.80^a	6.30 ± 0.82^a	8.19 ± 0.65^a	5.19 ± 1.11^a
Fe (mg/100 g)	3.08 ± 0.98^a	4.12 ± 0.96^a	2.70 ± 0.88^a	5.36 ± 1.03^a
Zn (mg/100 g)	1.09 ± 0.51^a	2.53 ± 0.77^a	0.55 ± 0.96^a	2.12 ± 0.97^a
Se (μg/100 g)	28.39 ± 0.82^c	19.85 ± 1.23^c	6.87 ± 1.22^b	10.15 ± 1.10^a

Note: Values represent mean ± standard deviation (n = 3 per caste). Means within the same row with different superscript letters are significantly different at $p < 0.05$ based on one-way ANOVA followed by Tukey's HSD test. Ca = Calcium; Mg = Magnesium; P = Phosphorus; Fe = Iron; Zn = Zinc; Se = Selenium

Correlation Relationship between Proximate Compositions of Termites

The correlation analysis revealed both significant and non-significant relationships among proximate composition parameters (Table 3). A strong positive correlation was observed between moisture content and fat content ($r = 0.86$, $p < 0.01$), indicating that higher moisture levels were associated with increased fat content across termite castes. In contrast, moisture content (MC) showed a significant negative correlation with dry matter content ($r = -0.59$, $p < 0.05$), reflecting the expected inverse relationship between these two components.

All other relationships among proximate parameters were comparable. Although weak to moderate associations were observed, such as the negative relationship between carbohydrate content (CC) and crude protein content (r = -0.47), and the positive association between CC and ash content (r = 0.39), these were not significantly different. Similarly, crude fibre content (CFC) exhibited weak, non-significant correlations with all other variables (Table 3).

Table 3: Correlation Matrix of Proximate Composition (g/100 g Sample)

Parameter	MC	DMC	FC	AC	CFC	CPC	CC
MC	1						
DMC	-0.59*	1					
FC	0.86**	-0.33^{Ns}	1				
AC	-0.18^{Ns}	-0.09^{Ns}	-0.13^{Ns}	1			
CFC	0.17^{Ns}	-0.49^{Ns}	0.31^{Ns}	0.26^{Ns}	1		
CPC	0.06^{Ns}	-0.07^{Ns}	0.22^{Ns}	0.00^{Ns}	0.14^{Ns}	1	
CC	-0.23^{Ns}	0.32^{Ns}	-0.11^{Ns}	0.39^{Ns}	-0.02^{Ns}	-0.47^{Ns}	1

Note: Values represent Pearson correlation coefficients. *Correlation is significant at $p < 0.05$; **correlation is significant at $p < 0.01$; NS = not significant ($p > 0.05$). MC = Moisture Content; DMC = Dry Matter Content; FC = Fat Content; AC = Ash Content; CFC = Crude Fibre Content; CPC = Crude Protein Content; CC = Carbohydrate Content.

Correlation Relationship between Mineral Compositions of Termite Castes

The correlation analysis of mineral composition revealed several significant relationships among elements, particularly among calcium (Ca), magnesium (Mg) and phosphorus (P), while most other associations were weak and not significantly different (Table 4). A strong positive correlation was observed between Ca and Mg (r = 0.74, $p < 0.01$), as well as between Ca and P (r = 0.72, $p < 0.01$), indicating that these minerals tend to increase concurrently across termite castes. Similarly, Mg showed a strong positive correlation with P (r = 0.76, $p < 0.01$), suggesting a closely linked distribution pattern among these macro-minerals.

In contrast, zinc (Zn) exhibited significant negative correlations with both Ca (r = -0.62, $p < 0.05$) and Mg (r = -0.64, $p < 0.05$), indicating that higher concentrations of these macro minerals are associated with lower Zn levels. However, Zn showed no significant relationship with P, Fe, or Se. All other mineral relationships were not significant. Although weak correlations were observed, such as a positive association between Fe and Se (r = 0.21) and negative associations between Se and other minerals, these were not significantly different (Table 4).

Table 4: Correlation Matrix of Mineral Composition (per 100 g Sample)

Parameter	Ca	Mg	P	Fe	Zn	Se
Ca	1					
Mg	0.74**	1				
P	0.72**	0.76**	1			
Fe	0.34^{Ns}	-0.29^{Ns}	-0.12^{Ns}	1		
Zn	-0.62*	-0.64*	-0.48^{Ns}	-0.06^{Ns}	1	
Se	-0.34^{Ns}	-0.20^{Ns}	-0.27^{Ns}	0.21^{Ns}	-0.20^{Ns}	1

Note: Values represent Pearson correlation coefficients. *Correlation is significant at p < 0.05; **correlation is significant at p < 0.01; NS = not significant (p > 0.05). Ca = Calcium; Mg = Magnesium; P = Phosphorus; Fe = Iron; Zn = Zinc; Se = Selenium

DISCUSSION

The observed variations in proximate composition across termite castes reflect clear physiological and functional differentiation within the colony. The higher moisture content in the Queen caste, coupled with lower dry matter content, is consistent with their reproductive role, which requires enhanced metabolic hydration and soft tissue maintenance. In contrast, the King caste exhibited lower moisture and higher dry matter content, suggesting a more structurally stable and less metabolically active physiological state. Similar caste-based moisture variation has been reported in *Macrotermes bellicosus* by Idowu *et al.* (2014), reinforcing the role of reproductive physiology in determining body water composition.

Fat content was relatively higher in the Queen caste compared to other castes, indicating greater energy storage requirements associated with reproduction. This aligns with Costa-Leonardo *et al.* (2013), who reported that reproductive termites accumulate lipid reserves to sustain egg production and long-term reproductive output. Such lipid enrichment highlights the energetic specialization of reproductive castes, distinguishing them from workers and soldiers, which prioritize structural and functional roles over energy storage.

Protein distribution further supports caste-specific nutritional specialization. The higher crude protein content in the reproductive castes (King and Queen) compared to workers suggests a diet and metabolic allocation favouring tissue development and reproductive investment. This pattern agrees with Tasaki *et al.* (2023) and Makore *et al.* (2025), who reported that reproductive termites receive nutritionally enriched diets to support colony productivity. Conversely, the lower protein content in workers reflects their carbohydrate-oriented diet, which supports locomotion and foraging activities rather than reproduction.

Ash and crude fibre contents showed minimal variation among castes, suggesting that mineral deposition and structural fibre components are relatively conserved traits across termite functional groups. This supports Ayieko *et al.* (2016), who noted that caste differentiation in termites is more strongly influenced by metabolic rather than structural composition.

Mineral composition further demonstrates functional caste differentiation. The relatively uniform calcium levels across castes suggest a shared requirement for structural integrity, particularly in exoskeletal maintenance. However, magnesium and phosphorus exhibited significant variation, with soldiers recording the highest levels. This is consistent with their physiological demands, as both minerals play critical roles in energy metabolism, neuromuscular activity, and exoskeletal reinforcement. The high Mg and P levels in soldiers align with Maxime *et al.* (2022), highlighting their importance in supporting defensive behaviour and high muscular activity. Magnesium, as a cofactor in ATP-dependent reactions, is particularly important for sustaining the energetic demands of soldier termites.

Trace minerals such as iron and zinc also exhibited caste-related distribution patterns. Workers and queens showed higher iron and zinc concentrations compared to soldiers and kings, reflecting their involvement in metabolic activity, foraging, and enzymatic processes. These findings are consistent with Mabelebele *et al.* (2022), who emphasized the role of Fe and Zn in oxygen transport, immunity, and enzyme regulation in insects. The lower iron levels in soldiers and kings further support the hypothesis that these castes have reduced reliance on iron-intensive metabolic processes, as previously suggested by Rumpold and Schlüter (2013).

Selenium exhibited the most pronounced variation among all minerals, with kings and queens showing substantially higher concentrations. This suggests enhanced antioxidative protection in reproductive castes, likely linked to their longevity and sustained reproductive function. Selenium is a key component of antioxidant enzymes such as glutathione peroxidase, and its elevated presence in reproductive termites may help mitigate oxidative stress associated with prolonged metabolic activity (Cheseto *et al.*, 2024). This pattern highlights a potential adaptive mechanism for reproductive survival and efficiency within termite colonies.

The results demonstrate that termite castes exhibit distinct nutritional and mineral profiles that correspond closely with their ecological roles within the colony. Reproductive castes are characterized by higher moisture, lipid, protein, and selenium levels, supporting reproductive longevity and metabolic stability. Soldier castes, on the other hand, are enriched in magnesium and phosphorus, reflecting their structural and defensive functions, while workers show intermediate mineral profiles consistent with their foraging and metabolic roles. These findings reinforce the concept of caste-specific nutritional partitioning as a key adaptive strategy in termite social organization.

CONCLUSION

This study provides baseline information on the proximate and mineral composition of different termite castes collected from FUNAAB, Abeokuta, Nigeria. The results demonstrate clear caste-related variation in nutritional composition, particularly in moisture, protein, carbohydrate, magnesium, phosphorus, and selenium levels, reflecting functional and physiological specialization within termite colonies.

The observed nutrient profiles highlight termites as a valuable source of essential nutrients, with reproductive castes enriched in protein and energy-related components, while soldier castes exhibit higher concentrations of specific minerals associated with metabolic and structural functions. These variations underscore the potential of termites not only as a nutritionally diverse food resource but also as a functional food with caste-specific nutritional advantages.

The findings reinforce the contribution of edible insects to sustainable nutrition, food security, and dietary diversification, particularly in regions where conventional protein sources are limited or costly.

However, to fully establish their nutritional and health potential, further studies are recommended on amino acid composition, fatty acid profiling, mineral bioavailability, and safety assessment, which will provide a more comprehensive evaluation for human consumption and potential commercialization.

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(Manuscript received: November 11, 2025; accepted: May 26, 2026).