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Nutrient Composition and Potential Contribution of Winged Termites (*Marcrotermes bellicosus* Smeathman) to Micronutrient Intake of Consumers in Nigeria

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Authors' contributions

This work was carried out between the two authors without any grant or financial aid from any source. Author OTA designed the study, author OAO collected and prepared the sample and both authors analysed, prepared, read through and approved the final manuscript.

Original Research Article

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ABSTRACT

Introduction: Edible insects, which are generally abundant, nutrient-dense, marketable, and economically valuable constitute important part of the diet of large population of Nigerians. Roasted Winged termite (*Macrotermes bellicosus*) is a popular insect relished by people living the traditional lifestyle, especially children, and is eaten as snack. Little is known about the nutritional importance and potential nutrient contribution of this insect.
Aim: To determine the nutrient and antinutrient composition of *Macrotermes bellicosus* as a means of reducing micronutrient malnutrition among the consumers.
Methods: Winged termites were collected during their nocturnal swarming and divided into two portions. One portion was used for fresh sample determination and the other portion roasted for ten minutes, de-winged and kept refrigerated inside a plastic container till when needed for analysis. Its proximate, mineral, vitamin and antinutrient composition were determined using official methods of analyses of AOAC, atomic absorption spectrophotometric method, and spectrophotometric methods (vitamins and antinutrients respectively).
Results: Roasted *Macrotermes bellicosus* as consumed contained 4.3g moisture, 36.7g

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protein, 34.3g fat, 23.2g carbohydrates, 1.2g ash, 96.30mg sodium, 162.50mg potassium, 226.50mg calcium, 358.50mg phosphorus, 1.42mg iron, 3.13mg zinc, 330.42µg retinol equivalent, and yielded 551.2 kcal of energy /100g portion. Level of phytates, oxalates, trypsin inhibitors, saponins and tannins was very low (< 0.3mg/100g portion), and cannot probably cause any health hazard or malabsorption when consumed in large quantities. 100g portion of roasted *Macrotermes bellicosus* can contribute 24.0% energy, 58.3% protein, 22.7% calcium, 51.2% phosphorus, 20.9% zinc and 33.0% retinol equivalent (vitamin A) and 60.0% of vitamin E to Recommended Dietary Allowances (RDAs) of adult consumers.

Conclusion: *Macrotermes bellicosus* is a highly nutritious insect, and it can serve as good source of protein, calcium, iron and zinc for its Nigerian consumers.

Keywords: Edible insects; Macrotermes bellicosus; nutrients; micronutrients.

1. INTRODUCTION

Insects link biodiversity conservation and human nutrition in a way that many other food sources do not. Edible insects are generally abundant, nutrient-dense, marketable, and economically valuable; and constitute an important part of the daily diet of a large proportion of the population in South-Western Nigeria [1]. The commonly consumed insects in Nigeria include winged adult termites (*Macrotermes bellicosus / Macrotermes notalensis*), adult crickets (*Brachytrypes spp*), adult short horned grasshoppers (*Cytacanthacris naeruginosus* unicolor), scarab beetle larvae (*Oryctes boas*), and larvae of butterfly and moth (*Anaphe spp*).

Insects often contain more protein, fat, and carbohydrates than equal amounts of beef or fish, and a higher energy value than soybeans, maize, beef, fish, lentils, or other beans [2]. The quantity and quality of proteins, lipids, vitamins, minerals and calories in edible caterpillars are comparable to those of beef, fish, lamb, pork, chicken, milk and eggs [3]; and they are many times higher in protein and fat than the plants upon which they feed [4]. The nutritional qualities of edible insects have been studied by various authors [5,6,7,8,9], and caterpillars of many species have been reported to be rich in potassium, calcium, magnesium, zinc, and iron, as well as B-vitamins [10].

Termites (social insects with colonies divided into 'castes' that include workers, soldiers, winged adults, a queen and a king) are the most widely consumed insects in Africa. Winged termites are highly attracted to lights, and are collected for consumption as they emerge in swarms during the rainy season [11]. Once roasted, the wings are removed either by sifting the roasted insects or by rubbing them between the palms. The finished product is either eaten or sold in markets in Western and Eastern Nigeria as a snack [1]. Roasted termites can also be sun-dried for future use. Over ten (10) different insect species were reportedly consumed by the people of Benue State, Nigeria, with the termite, (*Macrotermes natalensis*) having the highest mean frequency [12].

Dried *Marcrotermes bellicosus* was reported to be a good source of dietary protein, fat and micronutrients [1,13,14]; but little information is available on nutrition potential and antinutrient composition of winged termite in the literature. This study was therefore designed to determine the nutrient, antinutrient composition and micronutrient potential of winged termite (*Marcrotermes bellicosus*) as a means of combating micronutrient malnutrition especially among rural populace.

2. MATERIALS AND METHODS

2.1 Sample Collection and Preparation

Sample of *M. bellicosus* was collected around the premises of Institute of Agricultural Research and Training (IAR&T), Moore plantation, Ibadan, Nigeria during their swarming flights. The sample was divided into two portions. One portion was used for moisture content and fresh sample determination while the second was roasted for ten minutes over a gas cooker, dewinged, labelled as "Roasted sample" and kept in a freezer at - 4ºC till when needed for analysis before grinding.

2.2 Chemical Analyses

2.2.1 Proximate composition

Moisture content of the two samples was determined by air oven method (Gallenkamp, Model OV – 440, England) at 105ºC [15]. The crude protein of the samples was determined using micro-Kjeldahl method [15]. Crude lipid was determined by weighing 5 g of dried sample into fat free extraction thimble and plugging lightly with cotton wool. The thimble was placed in the Soxhlet extractor fitted up with reflux condenser. The roasted *M. bellicosus* sample was then extracted with petroleum ether and the crude lipid estimated as g/100 g dry weight of sample, and then converted to g/100 g fresh sample weight [15]. The ash content was determined by weighing 5 g of sample in triplicate and heated in a muffle furnace at 550ºC for 4 h, cooled to about 100°C in the furnace and then transferred into a dessicator to cool to room temperature, weighed, and ash calculated as g/100 g original fresh sample. Crude fibre was determined using the method of Saura-Calixto et al. [16]. The carbohydrate content was obtained by difference. Gross energy of the samples was determined using ballistic bomb calorimeter (Manufacturer: Cal 2k – Eco, TUV Rheinland Quality Services (Pty) Ltd, South Africa).

2.2.2 Mineral analysis

Potassium and sodium content of the samples were determined by digesting the ash of the samples with perchloric acid and nitric acid, and then taking the readings on Jenway digital flame photometer/spectronic20 [17]. Phosphorus was determined by Vanado-molybdate colorimetric method [18]. Calcium, magnesium, iron zinc, manganese, copper and selenium content of the samples were determined from the digested ash of the samples spectrophotometrically by using Buck 200 atomic absorption spectrophotometer (Buck Scientific, Norwalk) [19] and compared with absorption of standards of these minerals.

2.2.3 Vitamin Analysis

2.2.3.1 Vitamin A determination

Vitamin A was determined through ultraviolet absorption measurement at 328 nm after extraction with chloroform. Calibration curve of vitamin A acetate was made and sample vitamin A concentration estimated as microgram (µg) of vitamin A acetate.

2.2.3.2 Thiamine (Vitamin B_1) determination

Thiamine content of the samples was determined by weighing 1g of each sample into 100ml volumetric flask and adding 50 ml of 0.1M H_2SO_4 and boiled in a boiling water bath with frequent shaking for 30 minutes. Five milliliters of 2.5 M sodium acetate solution was added and flask set in cold water to cool contents below 50^0C. The flask was stoppered and kept at 45-50^0C for 2 hours and thereafter made up to 100 ml mark. The mixture was filtered through a No. 42 Whatman filter paper, discarding the first 10 ml. 10 ml was pipetted from remaining filterate into a 50 ml volumetric flask and 5ml of acid potassium chloride solution was added with thorough shaking. Standard thiamine solutions were prepared and treated same way. The absorbance of the sample as well as that of the standards was read on a fluorescent UV Spectrophotometer (Cecil A20 Model) at a wavelength of 285 nm.

2.2.3.3 Riboflavin (Vitamin B_2) determination

One gramme of each sample was weighed into a 250ml volumetric flask, 5ml of 1M HCl was added, followed by the addition of 5ml of dichloroethene. The mixture was shaken and 90 ml of de-ionized water was added. The whole mixture was thoroughly shaken and was heated on a steam bath for 30 minutes to extract all the riboflavin. The mixture was then cooled and made up to volume with de-ionized water. It was then filtered, discarding the first 20ml of the aliquot. 2 ml of the filterate obtained was pipetted into another 250 ml volumetric flask and made up to mark with de-ionized water. Sample was read on the fluorescent spectrophotometer at a wavelength of 460nm. Standard solutions of riboflavin were prepared and readings taken at 460 nm, and the sample riboflavin obtained through calculation.

2.2.3.4 Niacin (Vitamin B_3) determination

Five grammes of blended sample was extracted with 100ml of distilled water. Five millilitre of this solution was drawn into 100 ml volumetric flask and made up to the mark with distilled water. Standard solutions of niacin were prepared and absorbance of sample and standard solutions were measured at a wavelength of 385 nm on a spectrophotometer and niacin concentration of the sample estimated.

2.2.3.5 Ascorbic acid determination

Ascorbic acid in the sample was determined by titrating its aqueous extract with solution of 2, 6-dichlorophenol-indophenol dye to a faint pink end point.

2.2.3.6 Tocopherol (Vitamin E) determination

One gramme of sample was weighed into a 250ml conical flask fitted with a reflux condenser wrapped in aluminium foil, and refluxed with 10ml of absolute ethanol and 20ml of 1M ethanolic sulphuric acid for 45 minutes. The resultant solution was cooled for 5 minutes, followed by addition of 50ml of distilled water and then transferred into a separating funnel covered with aluminium foils. The unsaponifiable matter in the mixture was extracted with 5 x 50 ml diethyl ether. The combined extract was washed free of acid and dried over anhydrous sodium sulphate. The extract was later evaporated at a low temperature and the residue obtained was immediately dissolved in 10ml absolute alcohol. Aliquots of solutions of the sample and standard were transferred to a 20ml volumetric flask. 5ml absolute ethanol was added, followed by a careful addition of 1ml conc. HNO_3 and placed on a water bath at 90^0C

for exactly 30 minutes from the time the ethanol begins to boil. Rapid cooling under running water follows. The absorbance of sample solution was read at 470 nm.

2.2.4 Antinutrient analysis

Oxalate was determined by extraction of the samples with water for about three hours and standard solutions of oxalic acid prepared and read on spectrophotometer (Spectronic20) at 420 nm. The absorbance of the samples was also read and amount of oxalate estimated. Phytate was determined by titration with ferric chloride solution [20]; while trypsin inhibitory activity was determined on casein and comparing the absorbance with that of trypsin standard solutions read at 280 nm [21]. The tannin content was determined by extracting the samples with a mixture of acetone and acetic acid for five hours, measuring their absorbance and comparing the absorbance of the sample extracts with the absorbance of standard solutions of tannic acid at 500 nm on spectronic20 [22]. Saponin was also determined by comparing the absorbance of the sample extracts with that of the standard at 380 nm [21].

Chi square test was performed on the results obtained using SPSS version 15.0

3. RESULTS AND DISCUSSION

3.1 Proximate Composition

Table 1 shows the result of proximate composition of *M. bellicosus*. The fresh insect was high in moisture, crude protein, and crude fat content, but very low in carbohydrates, ash and crude fibre. Roasting *M. bellicosus* resulted in highly significant reduction in moisture content, with corresponding significant increase in its crude protein, fat, ash and carbohydrate value ($p<0.05$). The roasted insect was also very high in gross energy content. The observed high moisture content of *M. bellicosus* (Table 1) was in agreement with the values obtained for other insects in the literature, and also in line with values of moisture stated for fresh animal products of which up to 75% is made of water [23]. The observed high crude protein and fat content of the insect confirmed the assertion of some authors that insects are good sources of dietary proteins and lipids [2,3].

Table 1. Proximate composition of fresh and roasted *M. bellicosus* (g/100g)

Parameter	Fresh	Roasted
Moisture	45.0±0.03	4.3±0.01
Crude Protein	21.1±0.12	36.7±0.14
Crude Fat	26.9±0.20	34.3±0.31
Ash	0.4±0.02	1.2±0.02
Crude Fibre	0.2±0.02	0.3±0.02
Carbohydrates	6.4±0.03	23.2±0.13
Gross energy (Kcal /)	-	551.2±2.30

Roasting brought significant improvement in the nutrient content of *M. bellicosus* due to significant reduction in its moisture content ($p<0.05$). The insect is consumed in roasted form, hence, it can be a very good source of dietary animal protein, which is an important nutrient required for growth, maintenance of general body functions as well as protection against infections [24,25]. The fat content of the insect might contain mono and poly

unsaturated fatty acids [13] which are of health benefits for adults and important for the growth, cognitive and eye development of young children [26].

M. bellicosus was very high in gross energy, and this is believed to be due to its high fat content, as fat contributes more calorie than twice the contribution of carbohydrates and proteins. The high protein, fat and gross energy content of the insect qualifies it as a source of dietary animal protein and energy in boosting the nutritional quality of complementary foods for infants and young children from local foodstuffs.

3.2 Mineral Composition of *M. bellicosus*

Table 2 shows the result of mineral composition of fresh and roasted *Macrotermes bellicosus.* Fresh sample of *M. bellicosus* was high in phosphorus, moderate in potassium, calcium, sodium, zinc and copper, but low in magnesium, iron, and manganese. Roasting significantly improved the mineral content of the insect ($p<0.05$) especially calcium and phosphorus. This finding confirms the fact that processing improves nutrient availability in the processed food [27,28]. The observed significant increase in mineral content of roasted sample is believed to have resulted in the significant loss of moisture content of the insect leading to increase in the dry matter content of the roasted sample [29].

Table 2. Mineral composition of fresh and roasted *M. bellicosus* (mg/100g)

Parameter	Fresh	Roasted
Potassium	75.10±0.01	162.50±0.03
Sodium	19.80±0.00	96.30±0.03
Calcium	26.90±0.07	226.50±0.03
Magnesium	10.70±0.02	23.60±0.03
Iron	0.85±0.00	1.42±0.00
Phosphorus	146.30±0.06	358.50±0.02
Zinc	1.80±0.04	3.13±0.04
Manganese	0.96±0.03	2.27±0.04
Copper	1.90±0.00	4.50±0.04
Selenium (µg/)	0.01±0.00	0.07±0.00

Roasted *M. bellicosus* can be a good source of dietary calcium and phosphorus which are required for strong bones and teeth by all ages. It can also be a good source of zinc and copper which are required for proper enzymatic activities in the body. Zinc is required for growth, cell replication, fertility and reproduction, and hormonal activities among others [25,26]; hence the insect can be a good source of this mineral in infant complementary foods. *M. bellicosus* can also be a source of haeme iron. The presence of selenium in *M. bellicosus* is an added advantage for its suitability for consumption by all, as selenium has been implicated in antioxidant protective characteristics, preventing lipid peroxidation [26]. Its inclusion in infant complementary foods can serve as source of selenium in the foods.

3.3 Selected Vitamin Composition of *M. bellicosus*

In Table 3, roasting resulted in significant increase in the fat soluble vitamins ($p<0.05$), while it brought significant reduction in water soluble vitamins (B-vitamins and Vitamin C), as many of the water soluble vitamins are heat labile [25,26]. Roasted *M. bellicosus* is rich in fat soluble Vitamins (vitamin A, D, and E) (Table 3). This might be due to the high fat content of

the insect. Antioxidants such as ascorbic acid, vitamin A (beta carotene), and tocopherol, coupled with dietary fibre have been associated with prevention of nutritionally associated diseases such as cancers, diabetes, coronary heart disease and obesity [30,31]; and evidence of vitamins E and C playing a key role in decreasing the incidence of degenerative diseases is considered to be strong [32]. The presence of vitamins A and E in substantial amount in *M. bellicosus* coupled with selenium is suggestive of the fact that the insect possesses good antioxidant properties.

Table 3. Selected Vitamins composition of fresh and roasted *M. bellicosus* (mg/100g)

	Fresh	Roasted
Vitamin A (RE)*	11.37±0.03	330.42±0.12
Vitamin B1	0.87±0.02	0.09±0.01
Vitamin B2	0.32±0.01	0.01±0.02
Vitamin B3	1.59±0.03	0.85±0.01
Vitamin B6	1.09±0.02	0.27±0.02
Ascorbic acid	3.58±0.02	0.97±0.05
Vitamin D (µg/100g)	2.22±0.02	6.74±0.02
Vitamin E (µg/100g)	3.60±0.08	9.00±0.02

**RE = Retinol equivalent = 1 µg/100g.*

3.4 Antinutrient composition of roasted *M. bellicosus*

The insect was very low in antinutritional factors studied (Table 4). As expected, the levels of phytate, oxalate, saponins and tannins were highly insignificantly small since they are majorly found in foods of plant origin. The level of trypsin inhibitor is very low and cannot constitute any malabsorption or bioavailability of proteins from other sources.

Table 4. Antinutrient composition of roasted *Marcrotermes bellicosus* (mg/100g)

Phytate	0.003±0.00
Oxalate	0.008±0.00
Trypsin Inhibitor (Tiu/mg)	0.220±0.03
Tannin	0.008±0.00
Saponin	0.002±0.00

3.5 Nutrient contribution to Recommended Dietary Allowances by *M. Bellicosus*

Table 5 shows the possible contribution that *M. bellicosus* can make to nutrient intake of consumers. It can contribute significant amount of energy, protein, calcium, phosphorus, zinc, and vitamins A and E to nutrient intake of its consumers.

Table 5. % RDA contribution of roasted *M. bellicosus* to nutrient intake of consumers

	RDA*	*M. bellicosus*	% RDA Contribution
Energy	2300	551.2	24.0
Protein	63	36.7	58.3
Calcium	1000	226.5	22.7
Iron	15	1.42	9.5
Phosphorus	700	358.5	51.2
Zinc	15	3.13	20.9
Vitamin A	1000	330.4	33.0
Vitamin E	15	9.0	60.0

**Source: wardlaw (1999): perspectives in nutrition [33].*

4. CONCLUSION

Marcrotermes bellicosus is rich in protein and lipid, and is high in gross energy content. It is rich in calcium, phosphorus, zinc, vitamin A and vitamin E. It is a good source of antioxidants and is very low in antinutrients. It can serve as source of animal protein, and its inclusion in locally formulated infant complementary foods can be a promising and worthwhile exercise. Investigating its protein quality, fatty acid profile and micronutrient bioavailability is needed to confirm its suitability or otherwise as a good source of both protein and micronutrients in infant complementary foods.

COMPETING INTERESTS

The authors hereby confirm that there is no conflicting or competing interest concerning this article, as it is solely sponsored and conducted by them.

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