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Exploring the Nutritional Potential of *Microtermes obesi* Consumed by the Ethnic Communities of Baksa District, Assam, India

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

The practice of eating insects is widespread throughout the world. The use of edible insects in animal feed and human diet is being advocated on a universal scale as an alternative source of protein, lipids and micro - nutrients which is correlated with global food security. Termites are nutritionally endowed eusocial insects belonging to the order Isoptera. *Microtermes obesi*, a termite species has been a part of traditional cuisine among different communities of Assam. Therefore, the present study was assigned to investigate the presence of nutrient composition and antioxidant properties of *M. obesi*, an edible termite species collected from Baksa district of Assam. In the current investigation, the nutritional values recorded from *M. obesi* adult comprised of 7.68±0.02% moisture content, 45.15±1.97g/100gm crude protein, 8.40±2.05 g/100gm crude fat, 28.76±1.31 mg/100gm Na, 22.86±2.19 mg/100gm K, 108.36±2.18 mg/100gm Fe, 58.09±1.38 mg/100gm Ca,

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20.47±3.15 mg/100gm S, and 132.88±2.15 mg/100gm P. The biochemical contents such as total phenolic, total flavonoid and DPPH radical scavenging activity are recorded as 108.17±2.43 mg gallic acid equivalent (GAE)/100g, 58.06±3.26 mg quercetin equivalent (QE)/100g and 84.90±2.15% respectively. Findings of this study demonstrated the presence of rich nutritional and high antioxidant qualities in *M. obesi* termite species and also provided scientific validation on the entomophagy practice of *M. obesi* which can be consumed as alternative source of nutrient in animal feed with potential health benefits.

Keywords: Microtermes obesi; entomophagy; nutrient composition; edible termite.

1. INTRODUCTION

Insects are the most diversified group of creatures that plays essential roles in human diet throughout history. The practice of collection and consuming of different insect species is a common among 3071 ethnic groups from 130 countries all over the world. Almost 2300 species of insects belonging to 18 orders have already been reported edible and are being consumed worldwide [1]. Entomophagy—a very old practice of human civilization—has recently attracted increased attention from scholars and policy officials due to its significance in terms of nutrition, livelihood production, pest management and therapeutics. Insects are being promoted as a healthy food choice for humans by the Food and Agricultural Organization of the United Nations [2], which in 2013 noted the high nutritional content of insects and acknowledged insect farming as environmentally acceptable. Entomophagy is mostly practiced by indigenous people of Asia, Africa, Australia and Latin America [3,4]. In India Entomophagy is widely practiced among the tribal communities that represent the vibrant cultural legacy of these communities. A total of 255 edible insect species are found in India, in which most are wild insects while only small proportions are reared viz. silkworms [5,6]. North eastern region of India is a hub for natural resources involved in entomophagic practice of more than 200 insect species [4]. The area is well-known for its wide variety of entomophagic customs among aborigines who believed that eating insects offered health benefits in addition to providing sustenance. In all the states of north-east India, insects including grasshoppers, silkworms, water bugs, grubs of bees and wasps, termites, are mostly consumed as food, majority of these are part of their traditional medicine [7,8]. In Assam, 67 species of edible insects have been reported that belongs across 27 families and 8 orders of insects [9-14]. Termites a group of tiny eusocial insects belonging to the order Isoptera are widely distributed in tropical and subtropical areas where they play a significant role in ecosystems due to their sociality, extreme abundance and symbiotic relationship with microbes. In addition to their function in the nitrogen cycle through the food web, altering the soil's properties, mineralization and decomposition, termites are consumed by a large number of humans worldwide. Entomophagy of termites evolved due to the existence of energy-rich chemicals in them [15]. In India, 2% of Isopteran species are reported to be consumed, with termites accounting for the majority [5]. Consumption of termites is a popular practice among locals in the north-east part of India and previously, the consumption of *Macrotermes natalensis*, *Macrotermes bellicosus* and *Odontotermes obesus* were reported in different regions of Assam due to their nutritive value [4]. *Microtermes obesi* is another termite species consumed by many ethnic tribes of Assam. Larvae and adults are eaten as a delicacy, an alternate source of protein and as a pest deterrent. However, the detailed nutritional and biochemical properties of *M. obesi* termites are not yet explained. So, the present research aimed to provide scientific evidence on *M. obesi's* nutritional value in terms of their entomophagic practices as well as significant biochemical properties that might indicate their medicinal importance. Therefore, the present work aimed at studying and evaluating the nutritive values and antioxidant properties present in the *M. obesi* termite as well as their potential health benefits.

2. MATERIALS AND METHODS

2.1 Collection of *M. obesi* termites

On the basis of the information from the local people, *M. obesi* termites were collected from the selected villages of Baksa district, BTR, Assam (Plate 1), after obtaining proper permission from the local authorities. Insects were collected from the soil with the help of a spade and put in collection jars and were taken to the Department of Zoology, Barama College, Barama for preservation and further analysis.

2.2 Identification and Preservation

Immediately after collection some of the samples were preserved by freezing at -20^{0}C for 48 hours to render them inert. Following that, some samples were directly dipped into Pample's fluid before being transferred to specimen tubes containing 70% alcohol [16,12]. The samples were then delivered to the Shillong office of the Zoological Survey of India for accurate identification. A handful of the preserved samples were deposited as voucher specimens in the museum at Department of Zoology, Barama College as museum specimens.

2.3 Nutritional Indices Analysis of Adult *M. obesi*

2.3.1 Total moisture, crude protein and lipid contents

In order to calculate total moisture content of *M. obesi* adult termites, freezer killed samples were weighed (W1) and then dried in hot air oven at 103^{0}C for four hours. After complete drying, samples were cooled in desiccator, weighed (W2) again and the moisture content was expressed in term of percentage [17]. These were then grounded to fine powder used for further analysis.

$$\text{Moisture (\%)} = \frac{W1-W2}{\text{W1}} \times 100$$

Where, W1: Weight (gm) of sample before drying
W2: Weight (gm) of sample (gm) after drying

Crude protein, crude fat and mineral content were measured on dry weight basis (d.w.).

Crude protein content was measured by Micro-Kjeldahl Method [18] and expressed as percentage (g/100g). For calculating crude protein content, measured nitrogen content was multiplied by a factor of 6.25.

For crude fat content, Soxhlet method with petroleum ether (40^{0}C to 60^{0}C) was used and result was expressed as percentage (g/100g) [17].

2.3.2 Analysis of different mineral composition

Mineral composition was determined by using the method described in [19]. Mineral elements viz; Sodium (Na), Potassium (K), Iron (Fe), Calcium (Ca), Sulfur (S) were determined by using Perkin Elmer 3280 Atomic Absorption Spectrophotometer (AAS). To determine phosphorus (P) content vanadomolybdate method was used [20]. The values of all the minerals were expressed in mg/100g.

2.3.3 Analysis of different antioxidant properties

Total phenol content was estimated by following the protocol described by [21] and [22]. Result was expressed as mg gallic acid equivalent (GAE)/100g.

Total flavanoid content was estimated following the methods described by [23], [24] and [22] and final result was expressed as mg quercetin equivalent (QE)/100g.

2, 2-diphenyl-1-picrylhydrazyl (DPPH) Radical Scavenging Activity was determined by following the protocol of [25] and [26]. Ascorbic acid was used as a standard to measure the activity at 517 nm in a spectrophotometer and the scavenging activity of *M. obesi* was calculated by using the following formula.

$$\text{DPPH scavenging activity(\%)} = \frac{\text{Abs control} - \text{Abs sample}}{\text{Abs control}} \times 100$$

Where, Abs $_{control}$ = Absorbance of DPPH in Methanol
Abs $_{sample}$ = Absorbance of DPPH in sample extract

2.4 Data Analysis

Data for all the analysis were presented as Means± Standard Deviations (SD) and performed in triplicates. (n=3).

3. RESULTS

3.1 Identification of Species

The samples submitted to the Zoological Survey of India, Shillong office were identified as *M. obesi* adult termites.

a.

b.

Plate 1. *M. obesi termite* (a) Freshly collected adult *M. obesi* (b) Fried edible *M. obesi.*

3.1.1 Nutritional composition of adult *M. obesi* termite

The moisture content of worker *M. obesi* termite was recorded as 7.68±0.02% and the percentage of total crude protein present in the worker *M. obesi* adult insect was 45.15±1.97 gm/100gm. Also the total fat content recorded from the insect species was 8.40±2.05 gm/100gm (Table1). Varying composition of the micronutrient's mineral were recorded from *M. obesi* adult termite (Fig. 1). Among all the minerals, phosphorus was the highest (132.88±2.15) followed by iron (108.36±2.18), calcium (58.09±1.38), sodium (28.76±1.31), potassium (22.86±2.19), while sulphur (s) was the least (20.47±3.15) in the insect. Essential antioxidant properties were also recorded in high quantity in *M. obesi* adult worker. The recorded phenolic content was 108.17±2.43 mg GAE/100gm and the total Flavonoid content was 58.06±3.26 mg QE/100gm. The DPPH scavenging activity was also recorded in very high percentage (88.90±2.15%) in *M. obesi* adult insect (Table 2).

Table 1. Nutritional composition of *M. obesi* adult

Sl. No.	Nutritional indices	*M. obesi* adult termites (Mean ± SD)
1	Moisture content (%)	7.68±0.02
2	Crude protein (%) (gm/100gm d.w.)*	45.15±1.97
3	Crude Fat (%) (gm/100gm d.w.)*	8.40±2.05

*Values are expressed as means ± standard deviation (SD); number of replicates: 03; *d.w.: dry weight; results obtained after drying at 103^{0}C*

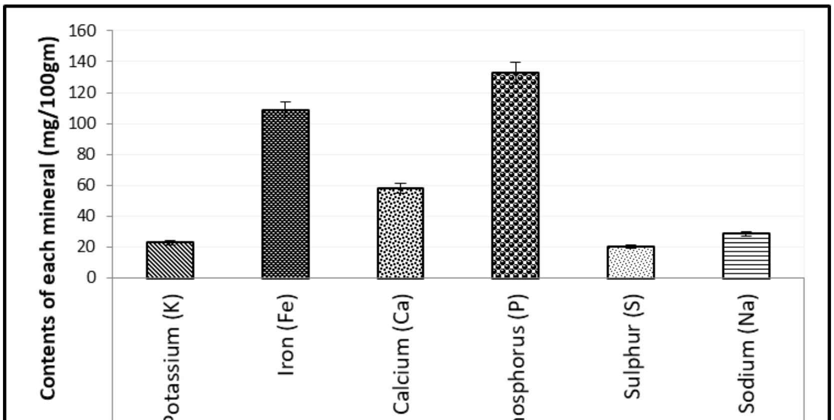

Fig. 1. Composition of some important minerals of adult *M. obesi* termite

Table 2. Antioxidants activity of adult *M. obesi*

Sl. No.	Biochemical and Nutritional indices	*M. obesi* adult termites (Mean ± SD)
1	Total Phenol content (mg GAE/100gm d.w.)*	108.17±2.43
2	Total flavonoid content (mg QE/100gm d.w.)*	58.06±3.26
3	DPPH scavenging percentage (%)	84.90±2.15

*Values are expressed as means ± standard deviation (SD); number of replicates: 03; *d.w.: dry weight; results obtained after drying at 103^{0}C*

The practice of entomophagy or eating insects, has gathered significant attention worldwide due to its high nutritive value and potential medicinal benefits. The trend of consuming insects is gaining attention and is likely to play a key role in mitigating the global food crisis while also contributing to overall health and livelihoods. In edible insects, moisture content is a crucial factor in determining their quality and safety. From this study it has been found that *M. obesi* termites are a good source of protein, minerals such as iron, calcium, phosphorus, sodium, potassium as well as sulphur and also source of antioxidants. The high DPPH scavenging percentage indicates that *M. obesi* has strong antioxidant potential. The biochemical and nutritional indices of *M. obesi* termites indicated that they are a promising candidate for use as a food source. Comparing these data with other edible insects gives a better understanding of the potential value of *M. obesi* as a food source. In the present study, moisture content of *M. obesi* adult workers was recorded as 7.68±0.02 % which is significant with the findings [27] who recorded less than 10 % Moisture content in five different edible aquatic insect species. The optimal moisture content in edible insects can vary depending on the species and intended use of the insect. Generally, the moisture content of edible insects should be below 15% to prevent spoilage and microbial growth [28]. Moisture content however can also vary due to alteration of certain environmental factors such as geographical location and habitat [27]. High-quality protein content in edible insects makes them a valuable addition in human diet especially in those regions where protein deficiency is common. In this experiment, *M. obesi* was recoded with high protein content (45.15±1.97). Similar findings were also reported in previous studies [29,30] where they found that Isopterans contain protein content ranging from 35% to 60% of their dry weight or 10% to 25% of their fresh weight. Additionally, Florence [31] reported that the protein content of termites was 14.2 grams. Another study [12] recorded protein content of 39.44 g/100g (dry weight) in *Macrotermes natalensis*. Likewise, similar findings were reported by [32], who examined the nutritional composition of various edible insects; including crickets, mealworms and grasshoppers and found the protein content ranged from 19.5-71.5%. The findings of present investigation are in agreement with these results, highlighting the rich protein content of termites and their potential as an alternate source of protein. Fat is another important parameter contributing to the overall energy requirement of humans. The fat content of insects is influenced by various factors such as habitat, sex, reproductive stage, season and diet [30]. In the current study, adult *M. obesi* was found to contain 88.40±2.05 g/100g (dry weight) of crude fat. Earlier research [33] recorded a lipid content of 133±7.21 mg/100g (fresh weight) in *Microtermes obesi*. During this investigation we have also recorded varying proportion of essential micronutrients in adult *M. obesi* termite. The micronutrient composition of edible insects is a crucial aspect to consider. Many researchers highlighted the abundant presence of various micronutrients, including copper, iron, magnesium, manganese, selenium, calcium, sodium, phosphorus, potassium and zinc, in different insect species [34-36]. Certain micro-elements like calcium and phosphorus play a significant role in bone development and strength [27]. In a previous study by [33], the calcium content in *Microtermes obesi* was reported to be 69.520 mg/100ml (fresh weight). In our present study, using the Perkin Elmer 3280 Atomic Absorption Spectrophotometer (AAS), we measured the calcium content to be 58.09±0.18 mg/100ml (dry weight), which closely aligns with the earlier findings. During spectrophotometric analysis, sulfur, an essential component of amino acids such as methionine and cysteine, was recorded at 20.47±0.15 mg/100gm (dry weight). Sulfur is necessary for humans as it maintains the integrity of protein structures by creating di-sulfide bridges. Importance of sulfur in human nutrition has been emphasized by [27] who found 16.89 to 26.45 mg/100g (dry weight) of sulfur in five coleopteran aquatic edible insects. Furthermore, our study revealed a substantial presence of iron content (108.36±0.08 mg/100g dry weight) in adult *M. obesi*, which falls within the permissible level for human consumption, making it an excellent alternative source of iron. However, the levels of two other micronutrient components, sodium and potassium, were recorded to be relatively low (28.76±0.31 mg/100g dry weight and 22.86±0.19 mg/100g dry weight, respectively) during spectrophotometric analysis. The thorough analysis of micronutrients in *M. obesi* showcases its rich composition of microelements and their potential significance in human nutrition. [33] previously analyzed the content of copper, iron, nickel, chromium, zinc, cadmium, lead, manganese, calcium and magnesium in *Microtermes obesi* and supported the notion of its rich micronutrient composition, all of which were found to be within permissible levels for human consumption. This comprehensive analysis adds further scientific validation to the entomophagic practice of consuming *M. obesi* termites as a nutritious food source. In our present study, we also recorded high activity phenolic, flavonoid and DPPH-scavenging activity. Including antioxidants in our diet offers several advantages for human health. These components strengthen the body's immune responses and enhance its resistance to various threats. Antioxidant molecules play a crucial role in neutralizing free radicals or reactive oxygen species (ROS) that are produced during the body's biological metabolism. One effective method of neutralizing free radicals is through scavenging, where different phenolic compounds present in a sample interrupt chain reactions of free radicals [37]. Phenolic compounds exhibit redox properties and can effectively hinder free radicals [37,27,38] and [39] have previously described the antioxidant activity resulting from the presence of phenols and flavonoids in plants and insects. The total phenolic content and flavonoid content were calculated to be 108.17±0.43 mg gallic acid equivalent (GAE)/100g and 58.06±0.26 mg quercetin equivalent (QE)/100g, respectively. It is worth noting that the phenolic content recorded in our study was found to be less than the lethal oral dose, indicating its safety for human consumption. [27] reported phenolic content in the range from 117.39 to 363.80 mg catechol equivalent/100g (dry weight) for five edible aquatic insects in Assam. Even in comparison to this data, our study shows a lower phenolic content; reinforcing its safety for consumption. During study high DPPH-scavenging activity was also recorded, (84.90±0.15%). All these result clearly indicates the presence of antioxidants in adult *M. obesi* termites which possibly adds valuable information to the existing knowledge. Overall, result of the present study provided further support to the potential value of *M. obesi* as a food source, mainly due to its optimal moisture content, high protein and lipid content, as well as essential minerals. Moreover, the high antioxidant activity observed in *M. obesi* termites indicates potential health benefits beyond their nutritional value.

4. CONCLUSION

Based on the biochemical and nutritional indices of adult *M. obesi* as well as comparisons with other edible insects, it appears that *M. obesi* could be a promising candidate for use as a food source. The high protein content, favorable amino acid profile and high levels of unsaturated fatty acids and minerals suggest that *M. obesi* could provide a valuable source of nutrition for human consumption. Additionally, the high antioxidant activity of *M. obesi* and other edible insects suggest that they could have potential health benefits beyond their nutritional value. The findings from present work provided a promising starting point for further exploration of *M. obesi* as a potential food source. However, further research is needed to fully evaluate the potentiality of *M. obesi* as a food source and to determine the feasibility of large-scale production and consumption.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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