Chemical Composition of Edible Soldier Termite (*Macrotermes bellicosus*: Isoptera) and Soil of termite Mound in Bayelsa State, Nigeria

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Abstract
Chemical composition of the edible soldier termite (ST) (Macrotermes bellicosus) and the soil of the mound (SM) was investigated. Proximate analysis showed that the M. bellicosus was higher than the mound soil in crude protein (16.25%:1.56%), fat content (8.42%:0.98%) and moisture content (64.5%:25.24%). The mound soil was higher than soldier termite in ash content (60.55%:5.83%) and carbohydrate (11.58%:3.62%) respectively. M. bellicosus provided greater average total energy of 188.09Kcal/100g, whereas the mound soil provided lower average total energy of 65.6Kcal/100g. Crude fibre was not detected in the mound soil but it was low (0.38%) in M. bellicosus. M. bellicosus contained higher amounts of four essential elements than the soil of mound: sodium (89.78mg/100g: 9.38mg/100g), calcium (320.9mg/100g:138.8mg/100g); potassium (426.6mg/100g: 64mg/100g) and zinc (26.24mg/100g: 9.35mg/100g), respectively. Mound soil contained higher amount of iron (266.92mg/100g) than the M. bellicosus which had lower amount of iron (123.97mg/100g). Both M. bellicosus and mound soil were poor in magnesium ranging between 0.43mg/100g to 0.17mg/100g, respectively. Cultural practice of pregnant women utilizing the soldier termite and mound soil as food provides good source of protein and mitigate against deficiencies in zinc and iron. They are also supplementary sources of potassium (426.6 mg/100g), calcium (320.9mg/100g) and sodium (89.79mg/100g) in human diets. M. bellicosus was found to contain acceptable amounts of phytate (11.8g/kg), high amount of tannin (94.8g/kg) and oxalates (224.36g/kg). Processing of the meal makes it safe to consumers by reducing there toxic levels.

Key words: *Chemical Composition, Macrotermes bellicosus, and mound.*

Introduction

There are over three thousand (3,000) species of termites found in all types of ecosystems of the world, except in the continent Antartica (Govorushko, 2019). Africa is the home for about 1,000 species of termites (Krishna *et al*, 2013). Sukuzi (1966) reported an approximate population of 2.5 million individual species of *Macrotermes* in about 70.5kg per hectare of farm land in tropical savannah of western Tanzania. In India, termites and its whole castes are used in pharmaceutical industries. In Eastern Africa, termite mounds are highly valued natural resources that are owned by individuals and families which consider it as legal property for inheritance when the owner dies. In western Kenya, some pregnant woman formed the habit of eating the clay soil of the termite castes, based on their cultural belief that it improves the growth of the fetus (Njiru *et al*, 2011 and Van Huis, 2017). In Eastern Nigeria, the matured winged termites (*Macrotermes nigeriansis)* are among the most popular edible insects which competes with the highly cherished palm weevil larvae, crickets and locusts (Nzelu, 2010). These insects when prepared as traditional meals are called "Nagpur" is a mixture of the mandibulate soldier termites and the workers obtained from the common termite hills found in the environment (Ramilingam, 1993). Scientists had stated that over 70% of the total population of edible termites harvested from their castes are the big headed soldiers (*M. bellicosus)* which protects the entire termite-hill from external invasion (Stone *et al*, 1999). Termites are also utilized as human food in other parts of Nigeria, as well as been used for rituals and medicine in some cultures in the Middle Belt of Nigeria (Angady, 2007). There are different methods of preparation and consumption of termites as traditional delicacy among various tribes in Nigeria such as the Bini, Igbo, Yoruba and Hausa. A traditional meal of termites of the Igbos is called Aku; the Hausa calls it Khiyea; the Yoruba calls it Esusun, whereas the Annangs of Akwa-Ibom State call it Ebu (Ntukuyoh *et al*, 2012). Earlier studies had reported that termites are good source of important nutrients such as proteins, minerals and vitamins (Banjo *et al*, 2006). Incidentally, the huge biomass of the mounds had been used as food and medicine in different parts of Africa and India. Termites are also important agents of environmental engineering and indicator of mineral deposits like gold, copper and heavy metals (including niobium, tantalum and tungsten) been a new branch of science currently known as geo-zoology (Surya Prakash Rao and Raju, 1984). Therefore, this study focused on evaluating the chemical composition of both soldier termite (*Macrotermes bellicosus)* and clay soils of the termite castes (mound) with the specific objective of assessing the nutritional potentials as food to humans and related animals. Although there are few information on the nutritional values of some species of termites in some parts of Nigeria, there are no report on the nutritional value of the mounds compared with the termites in Bayelsa State of Nigeria.

2.0 Materials and Methods

Source of Samples: The soldier termites and soil of the mound were collected by hired local farmers by cutting-open a section of an ant-hill (caste) in the humid rainforest of Anyama-Ijaw and Oporoma communities in Southern-Ijaw Local Government Area of Bayelsa State of Nigeria. Hoe and cutlass were used to dig-out the central portion of the termite castes to the chamber been formed by the workers. The hoe was used to collect some quantity of the clay soil along with the soldier termites and brushed into plastic containers and covered with a lid that had perforations for aeration and taken to the Food Science Laboratory of Rivers State University, Port-Harcourt, Nigeria. The samples were placed in an ice-bath which made them to be immobile and inactive. The soldiers were separated from the mound soil and put into separate containers and labeled.

Chemical Analysis:

The proximate composition of soldier termites and the soil of the mounds were analyzed using the Association of Official Analytical Chemists (AOAC, 2012) standard methods. Moisture was determined by oven drying method; ash content was obtained through the use of muffle furnace (550^{o}c), while crude protein content was determined by the Kjeldahl method and carbohydrate was determined by calculating the difference. The total energy value was calculated by the application of Atwater factors: 4.0 for carbohydrate and crude fiber; 4.1 for protein and 9.0 for lipids (Fox and Cameroon, 1989). The mineral composition of the samples was investigated using Atomic Absorption Spectrophotometer (AAS) techniques to determine the amount of calcium, iron, sodium, magnesium, potassium and zinc (Pomeranz and Meloan, 1971).

Determination of Anti-Nutritional Factors
The determination of three anti-nutritional factors which included phytates, oxalates and tannins of the soldier termite (*M. bellicosus*) using the methods reported by Ifie and Emeruwa (2011). The amount of phytate was determined using the method of Wheeler and Ferrel (1971); while the total oxalate content of the soldier termite was determined using the method of Day and Underwood (1986). The content of tannins was determined using the method adopted by Joslyn (1970).

3.0 Results and Discussion

The results in Table 1 revealed that soldier termite (*M. bellicosus*) is rich in protein, because it supplied 16.25% of crude protein, while the clay soil of the mound was poor in protein as it provided only 1.56% of crude protein on wet weight basis. The soldier termite also provided 8.41% of fat content, whereas the clay soil of the mound was poor in fat content as it

Table 1: Proximate Composition of Soldier Termite (*M. bellicosus*) and soil of Mound

Sample	Moisture	Ash	Crude protein	Fat	CHO (%)	Crude Fiber	Energy (Kcal/100g)
Soldier Termite (ST)	64.5 ± 0.01	5.83±0.03	16.25±0.07	8.41±0.10	3.62±0.05	0.38±0.001	188.09
Mound soil (MS)	25.24±0.04	60.55±0.10	1.56±0.00	0.97±0.01	11.58±0.02	ND	65.6

Values are mean ± SE (Wet weight %), ND means not detected.

provided only 0.97% of fat in 100g of mound. The soldier termite (*M. bellicosus*) and mound soil had 5.83% and 60.55% of ash content, respectively. Generally, there was low carbohydrate content of 3.62% and 11.58% for the soldier termite and mound soil respectively. Also, there was low fibre content of 0.38% in the soldier termite but it was not detected in the mound. The soldier termite provided a higher average total energy of 188.09 kcal/100kg, while the mound soil provided lower average total energy of 65.6 kca/100g. The results also had relatively high moisture content of 25.24% for the mound soil, while the soldier termite had higher moisture content of 64.5%.

The results in Table 2 revealed that both the soldier termites (*M. bellicosus*) and the mound soil are good sources of iron as it supplied 123.97mg/100g and 266.92mg/100g of iron, respectively. It was invincibly adduced from the results that most pregnant woman who consumes clay soil from termite hills are obtaining more than the recommended daily intake of 15mg/100g of iron. It was confirmed that the indigenous people of different ethnic groups who consume both the termite and the soil of termite castes will not suffer from anemia. We further recall that some women and youths who habitually consumes termites and soil of termite-hills were neither anemic nor suffered from kwashiorkor among the Igbos during the civil war in Nigeria (1967-1970); when there was scarcity of food due to the ban of food supplies to the eastern region (Gaman and Sherington, 1977). This study has confirmed that the clay soil of termite castes is a rich supply of 266.92mg/100g of iron which is involved in the production of blood vessels in humans. Therefore, taking a combined meal of soldier termites and clay soil of the mound would provide surplus amount of iron for healthy human life (HMS, 2018) These findings agreed with earlier reports which stated that some traditional

African and Indian communities had the belief that the utilization of termite mound as food for pregnant women would improve the growth of fetus by providing additional iron for the unborn child (Van Huis, 2017). The results also corroborated the recommendation that mound of termite castes will provide over 17% times higher than the recommended dietary allowance for iron in pregnant women (Njiru *et al*, 2011). Similarly, the consumption of soldier termites provides 26.24mg/100g of zinc which is higher than the recommended daily intake of 15mg/100g of zinc. On the contrary, the mound soil contained lesser amount of 9.35mg/100g of zinc which is lower than the recommended daily intake of zinc. However, a combination of soldier termites with clay soil of the mound would provide more than enough supply of zinc required for healthy living in humans. The soldier termites and mound soils were supplementary suppliers of 426.69mg/100g and 64.11mg/100g of potassium; 320.9mg/100mg and 138.8mg/100mg of calcium, while sodium was 89.7mg/100g and 9.38mg/100g. These values were serially lower than the recommended daily intake of 3,500mg/100gm of potassium, 2,400mg/100gm of sodium and 1,000mg/100g of calcium (HMS, 2018). The *M. bellicosus* and the mound soil were also poor in magnesium because both had negligible amounts which ranged between 0.43mg/100g to 0.17mg/100g which was lower than the recommended daily intake of 350mg/100g of magnesium (HMS, 2018).

Table 2: Mineral Composition of *M. bellicosus* and Mound soil (mg/100g wet weight)

Minerals	**Soldier Termite (*M. bellicosus*) (mg/100g)**	**Mound soil (mg/100g)**	**Recommended daily intake (mg/100g)+**
Iron	123.97	266.92	15
Zinc	26.24	9.35	15
Potassium	426.6	64.11	3,500
Magnesium	0.43	0.17	350
Calcium	320.9	138.8	1,000
Sodium	89.79	9.38	2,400

+ Recommended Daily Intake (Havard Medical School, 2018).

The results in Table 3 showed that *M. bellicosus* had a phytate content of 11.022g/kg which is lower than the phytic acid content of 178mg/100g reported in the edible larvae of *Orcyctes monoceros* (Ifie and Emeruwa, 2011). The amount of phytate in soldier termite falls below the detrimental range of 293mg/100g to 350mg/100g reported in boiled and fried locust flour respectively (Nafisa *et al*, 2008). This implies that the edible soldier termite (*M. bellicosus*) obtained from their natural castes are safe for consumption because there will be less negative impact of phytic acid reducing the availability of some essential elements including iron, calcium, potassium and zinc during digestion and absorption in humans (Erdman 1979; Ifie and Emeruwa, 2011). The results also showed that *M. bellicosus* had a high tannin content of 94.8g/kg which is considered as threat to the health of consumers because it falls within the detrimental range of 76g/kg – 90g/kg Dm for *Oryctes monoceros* and related insects (Aletor, 1995; Ifie and Emeruwa, 2011). Therefore, necessary precautions should be taken by consumers not to suffer from the risk of protein deficiency syndrome (Ekop, 2004). This study also showed that *M. bellicosus* had oxalate conent of 224.36g/kg which is higher than the recommended range of 200mg/100g to 500mg/100g (Pearson, 1977 and Alamu *et al*, 2013). Consequently, consumers of *M. bellicosus* should equally adopt appropriate safety measures against the negative effects of oxalic acid which reduces the availability of calcium, thereby impairing the formation of bones, teeth, poor clothing of bloods cells, as well as affecting the enzymatic reaction of co-factors in nerve impulse transmission (Ladeji *et al*, 2004). The degree of risk of consistent exposure to high consumption of oxalates is mitigated by the rapid breakdown of oxalates by "heat" during the preparation of the meal. The processing of edible insects also reduces the negative effects of tannins and phytates to non-toxic levels for safety consumption (Saluakhe *et al*, 1992). However, the impact of the anti-nutritional factors in edible insects need further investigation. The introduction of anti-nutritional elements in soldier termites which inhabit the same micro-habitat with other biota of the caste, could be attributed to its gregarious feeding habit on the cellulose of diversity of plants and wood-works which causes economic damage to man.

Table 3: Anti-Nutritional composition of soldier termite (*Macrotermes bellicosus*)

Parameter	Amount
Phytate (g/kg)	11.022
Tannin (g/kg)	94.8
Total oxalate (g/kg)	224.36s

Values are means of duplicate sample

Conclusion

The findings of this study have confirmed that the soldier termite (*M.bellicosus*) is more nutritious than the clay soil of the mound because it contained 16.25% of crude protein and 123.97 mg/100mg of iron, which is 8.27 times higher than the recommended daily intake of 15mg/100g of iron. *M. bellicosus* also contained 26.24mg/100g of zinc which is 1.75 times higher than the recommended daily intake of 15mg/100g of zinc and provided average total energy of 188.09kcal/100g. The clay soil of the mound was less nutritious when compared with the soldier termite (*M. bellicous*) because it contained only 1.56% of crude protein. However, the clay soil of the mound was richer in iron than *M. bellicosus* because it contained 266.92 mg/100g of iron, which was 17.8 times higher than the recommended daily intake of 15mg/100g of iron. The clay soil of the mound was poor in zinc as it contained only 9.35mg/100g of zinc which was less than the recommended daily intake of 15mg/100g of zinc. Therefore, it is recommendable for pregnant women and peasant households who are faced with famine to resort to harvesting edible soldier termites plus the internal layers of the castes and prepare it in combination with staple food stuffs for consumption to alleviate protein, iron and zinc deficiencies, as well as complement the amount of potassium, calcium and sodium in human diets. However, such geophagic practices should adopt appropriate food safety measures to prevent the intake of pollutants from the environment. It is importance to note that the soldier termites and the soil of the caste are potential food for humans and feed for livestock and aquaculture. Therefore, it is recommended that further studies be conducted on their reproductive biology, conservation and regeneration in captivity.

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