



Nutritional composition of Edible Termites (*Macrotermis bellicosus*) Consumed in Paikoro Local Government, Niger State, Nigeria

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ABSTRACT

The proximate composition, amino acid profile and fatty acid composition of Termites (*Macrotermis bellicosus*) commonly consumed by the indigenous tribes found in Paikoro local Government, Niger state were investigated using known analytical methods. The proximate analysis revealed crude protein to be 20.40 ± 0.2 %, crude fat 36.80 ± 0.3 % , moisture 2.82 ± 0.2 %,, crude fibre and total carbohydrate of 15.20 ± 0.3 % and 18.88 ± 0.06 % respectively. The insect was found to contain varying proportions of essential and non-essential amino acids with Leu/Ile ratio of 1.68. Also the insect was found to contain varying amounts of myristic, palmitic, Linoleic, stearic and Arachidic fatty acids. The high protein, fat and essential amino acids contents suggests that this specie of termites could serve as an alternative source of protein and other nutritional supplements in human and animal diets.

Keywords: Edible Insects, Termites, Nutritional composition, Amino acids, Fatty Acids

INTRODUCTION

From pre- historic times to the era of the cave-man, human beings utilized insects as ready source of food. Evidences from archaeology tell us that entomophagy (the habit of eating insects as food) has been practiced since mankind first made an appearance on this planet. Early records by Ene (1963), showed that the ancient Greeks and the Parthians, ate locusts and grasshoppers as food. The Epicureans of ancient Rome ate *Cossus* caterpillars, while the North American Indians fed on mountain locusts, ants, grasshoppers, crickets and warble fly grub (Sandel, 1745, cited by Ene 1963). In Europe, Asia, Australia and Africa, people feed on insects (Melo, 2010). The French feed on the abdomen of the beetle *Rhizotrogus assimilis*. Menzel and D' Aluiso, (2004) have reported that these insects provide high protein nutrients as well as concentrated sources of calcium, magnesium, vitamins, niacin and several other nutrients.

Ramos- Elorduy, *et al.* (1998), have estimated that over 50 species of insects are consumed throughout the year in Thailand in the larval (e.g. grubs and caterpillars) or the adult form (e.g. grasshoppers, termites, crickets). Entomophagy is frequently mentioned in ancient Greek and Roman literatures, for example, Roman and Greek scholars such as

Pliny the elder, Herodotus and Diodorus, recorded instances of eating insects (Alison, 2005). In United States and Europe, eating insects have increased not as a regular food, but exotic. Insects are for example covered in chocolates or offered as sugared candies (Sutton, 1988). Robert (1989) observed that a 10% increase in the World supply of animal proteins and fat through mass production of insects can largely eliminate the malnutrition problem and also decrease the pressure on other protein and lipid sources. The part played by insects in the nutrition, art, customs and beliefs of indigenous communities cannot be underestimated (Dunkel, 1998). People do not just eat insects, they relish them as delicacies. Insects commonly consumed are mostly those which can be collected in large numbers such as locust in the gregarious phase, winged termites, caterpillars, grasshoppers and the large African cricket, "*Brachytrupes*" (Ene, 1963). Also eaten occasionally and sometimes regarded as delicacies are fatty "grubs", green termites, larvae and pupae of beetles and the African silkworm caterpillar-*Anaphe spp.* (Fasoranti

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and Ajiboye, 1993). Ashiru (1988), have shown that entomophagy has contributed significantly to the reduction of protein deficiency in Nigeria. In Africa these insects are not only eaten as food but as delicacies, roadside snacks, and are considered tastier than meat (Alison, 2005). They are consumed in various forms (cooked, roasted/ fried, raw, or mixed with other ingredients depending on the type of insect). Hence, if suitably processed, they could add to the World's meager supply of protein and fats. Holt (1969) opined that, "the insects eat up every blessed green thing that grows and we farmers starve. Well, let us eat them and grow fat." He advocated the eating of a select list of vegetable eating insects, which he described as "clean, palatable, wholesome and nutritious". Gilmour, (1961) documented that insects contain many nutrients that are essential to humans. For example, they are known to have the same amino acid requirements as man, and so they actively accumulate these amino acids thus being a readily available source of these useful nutrients. DeFoliart, (1992), concludes that insects are really the forgotten food crop particularly because of the Western world's dominance on junk foods. He proposes adding nutritional value to staple diets, and maximizing ecological benefits with edible insects. In Nigeria, the favorite insects eaten are termites, grasshoppers, caterpillars, locusts, palm tree larvae, dung larvae (*Scarabeids*), crickets and composite beetle larvae. Many of these contain high quality fats and essential nutrients (Williams, 1991).

Termites (*Macrotermes bellicosus*), popularly called "Shinge" in HAUSA, "Aku" in IBO, and "Esusun" in YORUBA, belong to the Order –Isoptera, and family- Termitidae. They are gregarious insects commonly found in Nigeria during the rainy season. At the onset of a rainy season, male and female long – winged reproductive fly off from their nests in large numbers by a process called "swarming" (Collins, 1981). During this flight, known as the nuptial (or wedding flight), pairs of male and female termites isolate themselves from the others and fall to the ground. Their wings then break off and each pair goes its own way to form a nest in a suitable spot. In a new nest, the male reproductive is the potential king and the female, the potential queen (Malaka, 1996; Ekpo and Onigbinde, 2007).

The termites are usually attracted to sources of illumination at night and early hours of the mornings. They can be harvested by placing a bowl of water under a light source so that when they get attracted to the light, they are trapped and fall into the water. Termites are highly relished food items among various tribes in Nigeria and are considered highly nutritive. They provide important protein, lipids and vitamins (Defoliart, 1992; Ekpo and Onigbinde, 2007).

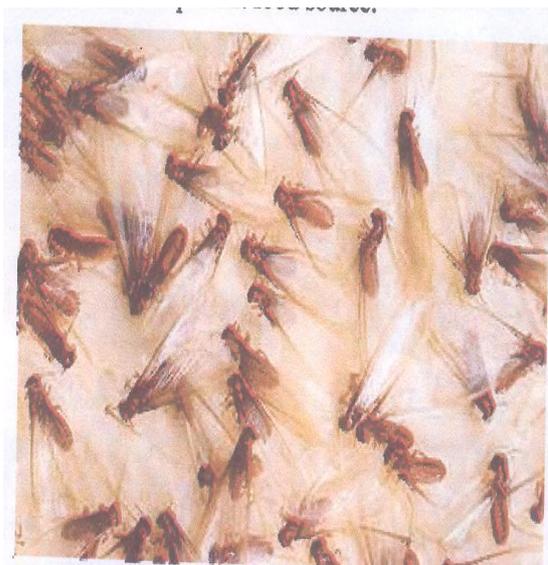


Plate 1: Termites - during their nuptial flight



Plate II: Termites on display for sale

The nutritional composition of these insects is acceptable and they are not just a traditional delicacy but contribute as a diet supplement. The overall information describing the chemical and nutritional composition of insects in Niger State is fragmentary and inadequate. A comprehensive data is therefore

necessary; hence the aim and objectives of the present study are to determine the fatty acid profile of the oils extracted from edible termites commonly consumed in Paikoro Local Government of Niger State and to evaluate the amino acid profile of the defatted samples with a view to establishing the nutritional potentials of the insects. This will produce a baseline data and a reference point for further researches on other edible insects from other areas.

METHODOLOGY

Sample collection and pre treatment

Sample of Termites (*Macrotermes bellicosus*) were collected during their nuptial flight at the onset of early rains between the months of May and July, 2017 under bright light at Paiko village of Paikoro Local Government area of Niger State. The samples were de-winged, sun dried for 72 hours to constant weight and made into powder with mortar and pestle until homogeneous. All the samples were identified by Entomologists in the Departments of Biological Sciences and Crop Science, Ibrahim Babangida University, Lapai. The dried samples were made into powder using laboratory pestle and mortar. They were sieved through a 2 mm mesh sieve and stored in plastic bottles for analysis. Triplicate determinations were made in each case.

Proximate and Mineral analysis

The moisture, ash and crude fibre contents were determined by the methods of Association of Official Analytical Chemists (AOAC, 2000). Total nitrogen (% N) was determined by the micro-Kjeldahl method, and Crude protein was obtained by using a Nitrogen-Protein conversion factor of 6.25. The oil (lipid %) content was obtained by extracting 5 g of the powdered sample with chloroform: methanol (2:1) mixture as described by Folch, Lees and Stanley modified method (1975). The solvent was evaporated on a rotary evaporator and the resultant oil dried in an oven at 60°C to remove traces of solvent. Percentage Nitrogen free extract (carbohydrate) was obtained by difference applying the formula

$$100\% - (\% \text{ protein} + \% \text{ lipid} + \% \text{ ash} + \% \text{ fibre}).$$

All determinations were in triplicate.

Fatty Acid and Amino acid Analysis

The oil in the sample was extracted using Folch's (Chloroform: Methanol mixture) method. The extracted oil was hydrolyzed and the fatty acids converted to their fatty acid methyl ester derivatives. The fatty acid methyl esters (FAMES) and their concentrations were determined using GC/MS spectrophotometer equipped with a detector. The fatty acids were observed as peaks whose retention times were measured by the Spectrometer detector and compared with those of known standards of the Wiley library.

Amino acid analysis was carried out at the Research laboratory of the Department of Food Science, University of Malaysia using WATERS 1525 Binary HPLC with multivalent fluorescence detector.

RESULTS AND DISCUSSION

The results of the proximate chemical composition of the species of termites (*M. bellicosus*) popularly consumed among the various tribes in Paikoro local Government is shown in Table 1.

Table 1: Proximate composition (% dry matter) of edible Termites

Parameter	Values (%)
Moisture	2.82 ± 0.20
Ash	5.90 ± 0.10
Crude Protein	20.40 ± 0.10
Crude Lipid	36.80 ± 0.20
Crude Fibre	15.20 ± 0.30
Carbohydrate (by difference)	18.88 ± 0.06

All given values are means ± SD of three determinations

The low moisture content of 2.82 ± 0.20 % indicates good shelf life characteristics. The low value suggests that this insect is not likely to be susceptible to micro-organism attack and can therefore be stored for a long period before deterioration. Banjo *et al.*, 2006, Paiko *et al.*, 2012 have reported higher moisture content of 4.4% and 5.10% for *C. forda* and short horn grasshopper (*Z. variegatus*) respectively. The crude protein content (20.40 ± 0.1 %), is similar to the value of 22.42 ± 0.1 % obtained by Paiko *et al.*, (2012) for dung beetle. The crude protein content is within the range of 15-60 % reported for various forms of Lepidoptera insects (Ramo-Elordy *et al.*, 1998). Ekpo *et al.*, 2009 reported crude protein

content of 35.18 ± 0.1 % and 33.41 ± 0.2 % in *I. belina* and *M. bellicosus* respectively. Thus, this insect could contribute to the recommended daily protein requirements of 23- 56 % recommended by National Research Council (NRC, 1980). The high ash content of 5.90 ± 0.1 % suggests that this insect could be a good source of minerals. Ife and Emeruwa (2011), reported ash content of 4 % for larva of *Oryctes monoceros*. Akinnawo and Ketiku (2000) obtained ash content of 7.12 % for larva of *Cirina forda*. The table shows high lipid content of 36.80 ± 0.3 %. Fats are essential and help in the transport of nutritionally fat soluble vitamins. Similar high fat contents of 31.46 % and 30.50 % were reported for *M. bellicosus* and dung beetle (Ekpo *et al.*, 2009 and Paiko *et al.*, 2012) respectively. High crude fibre and total carbohydrate (15.20 % and 18.88 %) were found in this insect. Subhachai *et al.* (2009), Ife and Emeruwa ,(2011) documented carbohydrate content of 12.40 % and 15.05 % for sun –dried edible ants and *O. monoceros* respectively. The high crude fibre and carbohydrate from this insect can be used to complement animal roughages.

Physico-chemical properties

Table 2. Physico-chemical properties of oil extracted from Termites.

Parameters	Values
Appearance	Light yellow
Specific gravity	0.9210 ± 0.03
Refractive index	1.245 ± 0.02
Solidification value (OC)	10- 12
Acid value (mgKOH/g)	3.72 ± 0.03
Free fatty acid (% as Oleic)	1.86 ± 0.01
Iodine value (g I ₂ /100g)	106.1 ± 0.1
Saponification value (mg KOH/g)	194.2 ± 0.2
Peroxide value (mEq O ₂ /Kg)	15.8 ± 0.3

Values are means \pm SD of three determinations

The results of some physico-chemical properties of the crude oil extracted from *M. bellicosus* are shown in Table 2. The oil is light yellow in colour and solid at room temperature with solidification temperature in the range of 10- 12⁰ C. This result is similar to the values of 12-14⁰ C reported by Ekpo, *et al.*, (2009) for oils of *M. bellicosus* and *R. phonicis* larval oils. The Specific gravity and Refractive index of the oil are 0.9210 ± 0.03 and 1.245 ± 0.003 respectively. The refractive index is a reflection of the optical clarity of the crude oil

sample relative to water. Edmond *et al.*, 2009, Paiko *et al.*, 2013 reported refractive index of 1.4542 ± 0.55 and 1.301 ± 0.01 for the oil from *Rhynchorus palmarum* L larva and *M. membranaceus* respectively. This implies that the oil from this insect is lighter and could be considered to be of high quality.

The Acid value of 3.72 ± 0.02 mgKOH/g and free fatty acid (% as Oleic) of 1.86 ± 0.01 were obtained. Acid values and free fatty acid content are important physico-chemical properties of oils used to indicate quality, age, edibility and suitability of oil. They are used to measure the extent to which triglycerides in the oil have been decomposed by lipase action and other physical factors such as light and heat. Ekpo *et al.*, (2009), quoted acid value of 3.60 ± 0.06 for *R. phoenicis* larva. The low acid value obtained in this work is a testimony to the freshness of the oil and suggests that these acids were not degraded during processing (Onyeike and Oguike, 2003).

From Table 2, the saponification value (mgKOH/g) of the oil from this insect is 194.2 ± 0.20 . Saponification value is an index of average molecular mass of fatty acids in an oil sample. It measures the free as well as chain – bounded fatty acids. The high saponification value of the oil in this insect indicates high proportion of fatty acids of low molecular weight, which makes it useful as a source of essential fatty acids required in the body (Akanni, *et al.*, 2005). Similar high saponification values of 190.30 ± 0.2 and 188.11 mgKOH/g for oils extracted from *B. membraceus* and *Componotus consubrinus* have been reported by Paiko *et al.*, 2013 and Mathew *et al.*, 2013 respectively. Ekpo, *et al.*, 2009, reported saponification values of 193.4 ± 0.3 and 198.9 ± 0.2 mgKOH/g for *M. bellicosus* and *R. phoenicis* respectively. The value of the saponification value of the oil in this insect is within the range for edible oils reported by Eromose, *et al.*, (1994). The Iodine value of 106.0 gI₂/100g was obtained from this work. Iodine value of oil is a measure of the degree of unsaturation of the oil. The value obtained in this work is comparable to those reported for most insect lipids suggesting a reasonable amount of unsaturated fatty acids. Ekpo *et al.*, (2009), have shown that *M. bellicosus* and *R. phoenicis* have iodine values of 108 ± 0.15 and 123.6 ± 0.24 gI₂/100g respectively.

The Essential Amino Acid profile is shown in Table 3(a). The result reveals that the insect is rich in essential amino acids such as Tryptophan, Lysine, Leucine, Isoleucine, phenylalanine and Valine.

Table 3a. Essential Amino acid (EAA) profile (g/100g) of Termites

Amino acid	Composition(g/100g)
Valine (Val)	1.237± 0.124
Tryptophan (Tyr)	2.749 ± 0.118
Threonine (Thr)	1.547 ± 0.039
Histidine (His)	1.215 ± 0.001
Methionine (Met)	0.766 ± 0.056
Lysine (Lys)	2.328 ± 0.303
Leucine (Leu)	3.343 ± 0.809
Isoleucine (Ile)	1.990 ± 0.426
Phenylalanine (Phe)	1.644 ± 0.002
TOTAL EAA	16.819

Values are means ± SD of duplicate determinations

Table 3 (b) also shows that termites contain Non-essential amino acids such as Aspartic, Serine, Glutamic, Arginine and Glycine.

Table 3b. Non-Essential Amino acid (NEAA) profile (g/100g) of Termites

Aminoacid	composition(g/100g)
Aspartic acid (Asp)	3.437 ± 0.057
Serine (Sr)	4.506 ± 0.031
Glutamic acid (Glu)	4.532 ± 0.158
Glycine (Gly)	1.903 ± 0.040
Alanine (Ala)	2.235 ± 0.110
Arginine (Arg)	1.987 ± 0.056
Proline (Pro)	2.004 ± 0.059
TEAA	16.819
TNEAA	20.897
Total Amino Acid analysed	37.716
TEAA/TNEAA Ratio	0.805
Leu/Ile	1.68

TEAA = Total Essential Amino acid

TNEAA = Total Non- Essential Amino Acid

The total essential amino acid (TEAA) is 16.819 g/100g, while the total non-essential amino acid (TNEAA) is 20.897g/100g representing 44.59 % and 55.41 % respectively. Ife and Emeruwa (2011) found the concentration of Valine in *O. monoceros* to be 2.64 g/100g. The value of Valine obtained in this work is lower than the value of 3.246 g/100g obtained by Paiko *et al.*, 2014 for Emperor moth caterpillar. The FAO/WHO/UNO (1985) recommended daily intake of Valine for adults is 26 mg/kg body weight. The insect revealed reasonable amounts of tryptophan, Lysine, Leucine and Isoleucine. Cereal based diets commonly found in developing countries could receive a boost with the inclusion of this insect in diet. Aspartic acid rejuvenates cellular activity, cell formation and metabolism. Glycine is involved in the transmission of impulses in the nervous system. Alanine strengthens the immune system and prevents build up of toxic substances in the body. A reported value of these amino acids in different insects and the recommended daily amount in adults is similar to the values in this work (Ghaly and Alkoaik, 2010, Paiko *et al.*, 2014, NRC, 1980).

The fatty Acid profile of the methylated oil from *M. bellicosus* is shown in Table 4. Nine fatty acids were identified made up of Myristic C14:0 (1.70 %), Palmitic C16:0 (2.47 %), Stearic C18:0 (2.77 %) and Arachidic (Eicosanoic, C20:0) 1.95 % acids as the dominant saturated fatty acids (SFA). The presence of both saturated and unsaturated fatty acids could be an advantage since both could compliment the function of one another. Paiko *et al.*, 2013, 2014, have observed similar high TUFA/TSFA ratio in the oil extracted from Cricket (*B. membranaceus*) and Emperor moth caterpillar from Bosso and Paikoro Local Government Areas of Niger State.

Table 4. Fatty acid composition of oil extracted from Termites.

Peak no.	Retention time	Fatty acid	Trivial name	Composition (%)
1	13.223	Methyl tetradecanoate	Myristic acid	1.70
2	15.048	1,1- Hexadecanoic acid, methyl	-	1.86
3	15.350	Hexadecanoic acid, methyl	Palmitic acid	2.47
4	15.704	n- Hexadecanoic acid	-	3.14
5	16.938	9, 12- Octadecadienoic acid	Linoleic acid	2.97
6	17.039	9- Octadecanoic acid methyl ester	-	3.72
7	17.255	Octadecanoic acid methyl ester	Stearic acid	2.62
8	17.577	Octadecanoic acid	Stearic acid	2.77
9	18.975	Eicosanoic acid methyl ester	Arachidic acid	1.95

Kayode *et al.*, 2010, have observed that in insects, fatty acids may be complex having odd numbers of carbon atoms, branched chains or contain a variety of functional groups including hydroxyl or keto groups. Palmitic and Myristic acids have been demonstrated to raise Low Density Lipoprotein (LDL), Cholesterol and are therefore considered atherogenic (Ife and Emeruwa, 2011).

Conclusion

This study has shown that the specie of termites consumed in Paikoro Local Government have the potential to provide substantial amounts of proteins, carbohydrates as well as crude fibre. The GC/MS analysis of the oil reveals the presence of both saturated and unsaturated fatty acids. The oil extracts exhibit good physicochemical properties with the potential to be developed for food and pharmaceutical industries. The presence of both Essential and Non- Essential Amino Acids could also be exploited so as to alleviate protein deficiency.

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