NUTRIENT COMPOSITION OF THE TERMITE MACROTERMES FALCIGER, COLLECTED FROM LUSAKA DISTRICT, A POTENTIAL AGENT AGAINST MALNUTRITION

By

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A dissertation submitted as partial fulfillment of the requirement of The University of Zambia for the award of a Master of Clinical Pharmacy Degree in Nutrition Support Pharmacy

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DECLARATION

I hereby declare that this dissertation represents my own work and has not been presented either wholly or in part for a degree at the University of Zambia or at any other University.

Signed…………………………………………..

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I have read this dissertation and recommend it for examination

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DEDICATION

I dedicate this work to my late father Mr. Fastone Chulu and my mum Mrs. Margaret Chulu, my brothers and sister for their unmatched efforts in teaching me to work hard. Many thanks to my husband Hussein Mussa and my son Mohammed Mussa for having being there for me all the way. May Jehovah continue blessing you.

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Abstract

Introduction

Roasted winged termites *(Macrotermes falciger)* are a highly relished insect, which are common in Zambia during the rainy season. The edible termites are de-winged, roasted and salted for use as a snack, either alone, or in combination with other foods. The main objective of the study was to evaluate the nutritional components of the termites *(M.Falciger)* with a view to revealing any possibility of its use as a possible complementary feed for combating malnutrition.

Methodology

An Analytical Laboratory experiment was conducted. Minimum Size of Lab Sample of 2kg of dry roasted termites was collected from Lusaka during the rainy season and used for proximate, mineral, vitamin and fatty acid composition. The termite (*Macrotermes falciger)* samples were analyzed according to official methods of analysis recommended by the Association of Official and Analytical Chemist (AOAC).

Results

Roasted *Macrotermes falciger* contained moisture(6.0 %±0.02), crude protein, (23.1%±0.00), crudefat(46.5%±0.01),Energy(591kcal/100g),Calcium(81±0.03mg/100g) zinc(5.3mg/100g), magnesium(132mg/100g), manganese(147.5,±0.01 mg/100g), selenium(22.2mg/100g), phosphorous (81mg/100g) .The total fatty acid content was 45.3g/100g The high fat content of the termite was made up mainly of unsaturated fatty acids (60.3%) .These values suggest that the winged termite, *Macrotermis falciger* has nutritional and pharmaceutical potential.

Conclusions

Macrotermes falciger is a highly nutritious food that can serve as a good source of protein, calcium, iron, zinc, vitamins, minerals and unsaturated fatty Acids that may be necessary for combating protein energy related malnutrition prevalent in Zambia. There is need for manufacture of complementary foods with components of termites as they are good sources of nutrients.

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ACRONYMS

AOAC	Association of Official and Analytical Chemists
FAO	Food and Agricultural Organization
Fe	Iron
HCl	Hydrochloric acid
HNO3	Nitric acid
H2SO4	Sulphuric acid
INFOODS	International Network of Food Data Systems
MDG	Millennium Development Goal
PEM	Protein Energy Malnutrition
PER	Protein Efficiency Ratio
UN	United Nations
UV	Ultra violet
WHO	World Health Organization

Chapter One

Introduction

1.0 Background

In Zambia over one million children under five years and 10 % of women of the reproductive age are malnourished. The common nutrition problems in these children include chronic malnutrition (45%), underweight (15%), wasting (5%) and low birth weight (10%). Micronutrient deficiencies in children under five years include vitamin A (54%) and iron deficiency anemia (53 %) (National Food and Nutrition Commission of Zambia, 2012), (World Health Organization, 2009). These rates are among the highest in the region. Despite every measure being taken to boost food production by conventional agriculture, including current interest focused on the possibilities of exploring the vast numbers of less familiar plant resources existing in the wild almost no interest has been shown to the consumption of insects, a traditionally recognized and available source of protein and fats.

Insects have played an important part in the history of human nutrition in Africa, Asia and Latin America (Bodeinmer, 1951). According to FAO (2010), more than 2.5 billion people mainly from Africa and Asia commonly eat insects. Ordinarily insects are not used as emergency food during shortages, but as a planned part of the diet throughout the year or when seasonally available(Banjo *et al*, 2006).The edible insects have been reported to have more nutritional content than other conventional foods(Siulapwa *et al*, 2013).Studies on the nutrient analysis of various insects have shown that they are rich sources of fat, vitamins and minerals, especially iron and zinc (Durst and Shono, 2010, Kinyuri *et al*,2010 and Omotoso and Adedire,2005**).** Insects are valuable sources of animal protein for Zambia’s rural population since meat from domesticated and wild animals are scarce (Mwizenge, 1993). The most commonly edible insects in Zambia are of three species, these include two species of Order Lepidoptera (*Gonimbrasia belina* and *Gynanisa maja*, one species of Order isoptera (*Macrotermes falciger*, and one species of Order Orthoptera (*Ruspolia differens*) (Siulapwa *et al*, 2013). The insufficient availability of animal protein sources, and the high cost of the few available plant sources have prompted an intense research into the possible exploitation of the nutrient potential of insects, especially the African edible termites.

Macrotermis falciger is a gregarious insect, which in Zambia is common during the rainy season. During its 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. They begin by making a few tunnels in the ground. In a new nest, the male reproductive is the potential king and the female, the potential queen. (Ekpo and Onigbinde, 2007). In Zambia, when winged termites emerge in dense numbers, they are eagerly collected. They emerge with the first rains. The termite is usually attracted to sources of illumination at nights and may be found, also, in the early hours of the mornings. The termites are harvested by placing a bowl of water under a light source. Attracted to the light they get trapped when they fall into the water. The usual steps in the processing of the insect include de-winging, roasting and salting, or grounding into flour for use as snack food, either alone, or in combination with other foods. It is a highly relished food item in Zambia. The termite is known by various names by the different ethnic groups in Zambia who strongly believe it to have high nutritive value. With the recent wave of economic depression and its effect on the purchasing power of the Population of less developed nations, it has become obvious that the local food stuffs will play increasing role in the food and nutrition security of the rural people and the increasing urban poor.

Despite the popularity of *M. Falciger* as a delicacy in Zambia and other African countries, little Information is available on its nutrient potential in the literature. This study was therefore designed to determine the macronutrient, and micronutrient potential of winged termite (*Marcrotermes falciger*) to provide data on the proximate, micro-elemental, macro-elemental, and fatty acids compositions of this termite delicacy, as a prerequisite for the subsequent evaluation of its nutritional and pharmaceutical potential and to draw inferences on its possible use to combat malnutrition especially among rural populace.

This study intended to examine the nutritional value of *Macrotermes falciger*, locally known as “inswa” collected from Lusaka District which is eaten in several parts of Zambia, as food composition data forms part of evidence basis in support of initiatives on nutrition and biodiversity.

1.2. Statement of the problem

In Zambia nearly half (45%) of households are food insecure as defined as per capita access to calories. Many more households likely lack access to diverse diets year round (FAO. 2009).

WinFood, a project funded by the Consultative Research Committee for Development Research and DANIDA in Denmark aims to contribute to alleviating child malnutrition by focusing on traditional food systems based on semi-domesticated or wild indigenous plant or animal foods (such as fruits, roots, small fish, snails, frogs and insects) FAO. Edible insects: future prospects for food and feed security, 2013). Insects are a good alternative to the serious worldwide nutrition problem as a result of good quality protein deficiency among low income people. Their consumption is all over the world, therefore is important, to improve production and preservation techniques, to market them for availability to all populace (FAO. Edible insects: future prospects for food and feed security, 2013).

Very few studies have been done to determine the actual nutrient composition of these insects including *Macrotermes Falciger* so as to apply this data in the various realms of public health nutrition drawing the connection between what we eat and how we live.

Studies on *Macrotermes sp*. have been done mostly in West Africa on *Macrotermes bellicosus* (Ntukuyoh *et al*., 2012) and East Africa on *Macrotermes notalensis* (Kinyuri *et al*,2010). The information gained from these studies cannot be applied to the Zambian setup as the nutritional value of foods differs according to environmental/climate factors. There is a difference in species as will be noted in the literature review because the species vary depending on the location. Most of these studies have looked at part of the nutrient content but leaving out other aspects like the fatty acid content for example. Only one study has been done in Zambia on the nutritional value of *M.Falciger* which is predominant in Zambia. This study looked at the proximate composition, mineral composition (Siulapwa *et al*, 2013). This study left out the vitamin and fatty acid profile which are very vital if this termite is to be used as antidote to malnutrition. It also looked at termites collected from the copper-belt region of Zambia which may differ in composition with the ones collected from Lusaka District due to different climatic zones. It is therefore from this point that this study was being undertaken.

1.3. Aim of study

This study was aimed at evaluating the nutritional components of the termites *M.Falcige*, collected from Lusaka District with a view to revealing any possibility of its use as a base for the formulation of new food/feed products as possible means of combating malnutrition.

1.4. Objectives

General objective

The main objective of this study was to examine the nutrient content of termites (*Macrotermes falciger)*, locally known as "*INSWA*" as possible means of combating macronutrient and micronutrient deficiencies among the consumers through chemical analysis.

Specific objectives

i. To determine the proximate (Moisture, crude protein, crude lipid, ash, crude fibre and carbohydrate) content of *M.falciger* collected from Lusaka District.
ii. To determine the mineral content (Sodium, Potassium, Magnesium, Manganese, Zinc, Calcium, Selenium and Phosphorous) *of M.falciger* collected from Lusaka District..
iii. To determine the vitamin content (Vitamin c) of *M.falciger* collected from Lusaka District.
iv. To determine the fatty acid content (full fatty acid profile) of *M.falciger* collected from Lusaka District.

1.5. Research question

What is the nutritional value content of the termites *Macrotermes falciger* found in Lusaka district of Zambia?

1.6. Study justification

Malnutrition rates in Zambia have remained virtually unchanged since the early 1990s, and with business as usual, Zambia may not meet MDG 1c which states: "Halve, between 1990 and 2015, the proportion of people who suffer from hunger." High rates of hidden hunger indicate that dietary diversity may be low. That is why the UN through FAO is promoting dietary diversity by encouraging the practice of entomophagy, because insects are healthy, nutritious alternatives to mainstream staples. Many insects are rich in protein and good fats and high in calcium, iron and zinc. (FAO, 2013)

The need for high quality food composition data is being increasingly recognized worldwide and investing in this area will result in significant benefits in improving public health nutrition. The discovery of bioactive substances and their health promoting effects in foods has led to a rise in the demand for food composition data which goes beyond nutrients and energy**.**

In clinical practice, knowledge of a nutrient composition table is vital in the prescription of diets containing known amounts of nutrients for the treatment of certain diseases as well as in correcting the nutritional values of a given diet (Rolfes *et al*, 2009).

A therapeutic diet must be nutritionally balanced and adequate while at the same time controlling the intake of one or more specified nutrients. The prescription of therapeutic diets, therefore, requires professional training and a detailed understanding of the composition of foods. Nutrition interventions, such as food aid programs, supplementation schemes and disease prevention programs, require the use of food composition data in order to translate specific nutrient needs into food requirements (Roth *et al,* 2003). Note that such program may require confirmation by direct analysis, particularly at the research level. It is in the same vein that a study like this one came in.

Moreover, The International Network of Food Data Systems (INFOO DS), established in 1984, aims to stimulate and coordinate efforts to improve the quality and worldwide availability of food analysis data. INFOODS and FAO are collecting data on food composition and consumption in order to promote biodiversity (FAO, 2013). Therefore the information gained from this study would be of great value not only to the consumers but also to the policy makers. The study brought into focus the classes of nutrients present in *Macrotermes falciger*, to show its proximate, mineral, vitamin c constituents and revealed its fatty acid profile for possible domestic and clinical use.

Chapter Two

2.0. Literature review

Starting in the 1970s, the nutritional value of dried insect meals has been evaluated when they were fed as the primary source of dietary protein. This data is important as it represents evaluations of insect protein quality based on both amino acid analysis and animal feeding trials. These studies indicate insects to be good sources of essential nutrients, which could help solve most nutritional problems in developing countries. (Banjo *et al*, 2006)

Studies on the nutritional value of winged termites *Macrotermes sp*. have been done mostly in Nigeria on *Macrotermes belicosus*(Ntukuyoh *et al.,* 2012) and East Africa on *Macrotermes notalensis* (Kinyuri et al,2010) which are commonly found there.A more recent one in Zambia on *Macrotermes falciger*(Siulapwa *et al*), which is mostly found in Zambia. There is a difference in species with reference to M.falciger as will be noted in the literature review because the species vary depending on the location. Both of these studies have looked at part of the nutrient content but leaving out other aspects like the fatty acid content for example.

Ekpo (2011) in an experimental study done in Nigeria studied the nutritional and biochemical evaluation of the protein quality of some popular insects consumed in Southern Nigeria. Thirty six (36) young weanling male albino rats (Wistar strain) of about 23 days old, grouped into six (6) groups of six (6) animals per group, were fed separate diets containing 10% protein by weight of the test diets, casein diet and a protein free (corn starch) diet for twenty eight (28) days. The diets contained adequate amounts of all other required nutrients. Results showed that the (Protein Energy Ratio)PER of the insects expressed as a percentage of that obtained for casein were 94.26%, 71.31%, 96.72% and 107.38% respectively. These observed results suggested the insects to be good sources of essential nutrients, which could go a long way in helping to solve most nutritional problems in many developing countries. His recommendation was that entomophagy should be encouraged as a good alternative towards solving the PEM problem facing many third world countries. While we concur with the above statement our study also looked at other nutrients apart from the protein emphasized.

Another analytical laboratory experiment conducted by Ntukuyoh *et al* in the Niger delta of Nigeria in 2012 where Queen, soldiers and workers of termites (*Macrotermes bellicosus,*another species of these termites) were analyzed for proximate composition, vitamin, mineral elements and anti-nutrient content. Proximate composition showed that crude protein content of the soldiers was higher than those of workers and Queen. The highest mineral element was sodium in queen, while the least mineral was manganese in the soldiers. .(Ntukuyoh *et al*.,2012).

Banjo *et al (*2006) analyzed seventeen species of edible insects representing nine families from south western Nigeria were analyzed for nutrient composition. Despite the absence of a full vitamin and mineral profile *Macrotermes bellicosus* and *Macrotermes notalensis* were found to have the highest iron content.at 29 mg/100g and 27 mg/100 g respectively. It was concluded that that the differences in nutritional content of edible insects may be due to variations in the dietary habits of the insects or as a result of different ecotypes and age of the insects. That is why it was necessary to carry out this study in Zambia so as to know the exact nutritional content of *M.falciger*.

A similar study by Adepoju and Omotayo was designed to determine the nutrient, anti-nutrient composition and micronutrient potential of winged termite (*Marcrotermes bellicosus*) as a means of combating micronutrient malnutrition especially among rural populace in Nigeria. This was another analytical laboratory experiment. This study concluded that investigating the protein quality, fatty acid profile and micronutrient bioavailability of *M.bellicosus* is needed to confirm its suitability or otherwise as a good source of both protein and micronutrients in infant complementary foods (Adepoju and Omotayo, 2013).

A more recent study was done in Zambia to assess the nutritional value of four commonly edible insects in Zambia. The insects studied include the caterpillars (*Gonimbrasia belina* and *Gynanisa maja*), grasshopper (*Ruspolia differens*) and winged termites (*Macrotermes falciger*).According to this analytical laboratory experiment the insect richer in carbohydrates (32.8 %±0.7) was *Macrotermes falciger,* while the insect with a least value was *Gonimbrasia belina* with carbohydrate content of 7.8 % ±0.5. The highest amount of energy of 810.2 kcal/100g was recorded in *Macrotermes falciger*. Lysine was the most predominant essential amino acid in *Gynanisa maja* (4.02g/100g), *Ruspolia differens* (5.74g/100g) and *Macrotermes falciger* (3.72g/100g), while arginine was the most predominant in *Gonimbrasia belina* (4.57g/100g).

The nutritional content of the insects was generally higher than that found in common meats (Siulapwa *et al*, 2013).This study however left out the vitamin and fatty acid profiles which Thisstudy encompassed. This study was aimed at filling the gap and lead to a greater understanding of the nutrient content of *macrotermes falciger* found in Zambia since no comprehensive study has been done with regard to this.

Chapter Three

3. Research methodology

3.1. Study design

The study was an analytical laboratory experiment**.**

3.2. Study site

The study was carried out at the National institute for scientific and industrial research laboratory in Lusaka. All analyses (proximate, ash, crude protein, carbohydrate, fat, energy, minerals and vitamins) except the fatty acid profile were carried out at the above institution. There was a need to send samples abroad for fatty acid analysis as they could not be done locally; as such, samples were sent to Biochemical and Scientific Consultants of Port Elizabeth, South Africa.

3.3. Study population

Edible winged termites *(Macrotermes falciger)* collected from Lusaka District.

3.4. Study population site

Lusaka whose geographical coordinates are 15° 25' 0" South, 28° 17' 0" East has a pleasant tropical climate with three seasons: a cool dry season (April–August), a hot dry season (August–November) and a warm wet season, which is even hotter, (November–April).The mean maximum temperature is 31.6 in the hot season and the mean minimum temperature is 10.1in the cool season. Average rainfall is about 800mm.

The actual population site is a popular winged termite (*Macrotermes Falciger*) collection site for locals which is Lusaka water works substation (15°27'19.98" South,28°19'7.98" East).This area was an ideal population site because it lies in the *Miombo* Agro-ecological zone and there are a lot of termite mounds dotted around the area.

3.5. Study sample

a. **Sample size**

Minimum Size of Lab Sample of 2kg of dry roasted sample was collected.1.5 kg of the sample was used locally for proximate, mineral, and vitamin analysis at the National

Institute for Scientific and Industrial Research laboratory whilst 0.5kg was sent to Biochemical and scientific Consultants for fatty acid analysis.

b. Sample Collection and Preparation

Edible termites *(M. falciger)* were randomly collected from during their nuptial flight at the Lusaka Water Works Sub-station (Lusaka district) in November just after the first rains. A basin of water was placed under a light source to trap the termites into the water. The sample was removed from the basin of water and was roasted for ten minutes over a gas cooker and de-winged. The dried sample was milled with a blender into a fine powder and transferred to a 500ml wide reagent bottle labeled as "Roasted sample" and kept at room temperature in a dark place until when it was needed for analysis before grinding.

3.5. Data collection/analysis

Data was collected through repeated measurements of chemical analyses and was expressed in form of tables and graphs and presented as the mean. The termites *(Macrotermes falciger*) samples were analyzed according to official methods of analysis recommended by the Association of Official and Analytical Chemist *(*AOAC) as outlined below.

a. Proximate Composition

Moisture content of the two samples was determined by air oven method (Gallenkamp, Model OV – 440, England) at 105°C. The crude protein of the samples was determined using micro-Kjeldahl method. 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. falciger* 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. The ash content was determined by weighing 5 g of sample in triplicate and heated in a furnace at 550°C 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*. The carbohydrate content was obtained by difference.

b. Mineral analysis

Potassium and sodium content of the samples was 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. Phosphorus was determined by vanado-molybdate colorimetric method. Calcium, magnesium, iron zinc, manganese, and selenium content of the samples was determined from the digested ash of the samples spectrophotometrically and compared with absorption of standards of these minerals by using a spectrophotometer (and compared with absorption of standards of these minerals.

c. Vitamin Analysis

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.

d. Analysis of the Lipid Extract:

The oil in a portion, 5g of the ground sample was extracted for 8 hours with 20ml of 1N hexane. Then 0.8g of the extracted oil was saponified for 1 hour with 15ml of KOH in methanol at 90°C, treated with 2ml of1.4N HCl for another 1 h and allowed to cool to room temperature. To the cooled solution, 15ml of N-heptane and 200ml of brine were added, mixed thoroughly and 5μl of the fatty acid methyl esters(FAMEs) solution was analyzed with the aid of a High Performance Gas Chromatography system for the fatty acids content. The FAMEs extract was co-analyzed with authentic FAME standards of known structures. The oil was extracted by solvent extraction method using acetone. The oil was separated from the solvent by heating, after which the oil was collected as the residue.

Microsoft Excel spreadsheet was used for all statistical calculations. Data was expressed as mean+ or – standard deviation. The results were presented in tables which contain the arithmetic mean :

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \ldots x_n}{n} = \frac{\sum_{i=1}^{n} x_i}{n} \quad (1)$$

And the standard deviation *SD* of a set of experimental measurements given by the following equation:

$$SD = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} \quad (2)$$

3.7. Ethical considerations

This study did not involve human participants directly. However, permission was sought from the National institute for scientific and industrial research Laboratory and Biochemical and Scientific Consultants of South Africa to carry out the study at the respective institutions.

Clearance was obtained from the Excellence in Research Ethics and science(ERES CONVERGE IRB).

It is extremely important that scientific results are trustworthy because scientific results are generally made public and accessible to all and in a field such as medicine, an immense number of people could be put in harm's way because of decisions made on the basis of false information. That is why this study observed honesty in all regards.

Chapter Four

4.0. Results

The quantitative estimations (in percentages) of the proximate compositions of *M. Falciger* are shown in Table 1 and Figure 1. The termite sample contains relatively high contents of lipid (46.5 ± 0.01%), protein (23.1%) and carbohydrate (16.5 ± 0.00%). The moisture, ash and crude fibre contents were 6.0 ± 0.02%, 5.7 ± 0.05% and 2.2 ± 0.48% respectively.

Table 1 Proximate and energy composition of the termites.

PARAMETER	SAMPLE CONTENT
Moisture (%)	6.00±0.02
Total Ash (%)	5.70±0.05
Crude Protein (%)	23.1±0.00
Crude fat (%)	46.5±0.01
Carbohydrate (%)	16.5±0.00
Crude fibre (%)	2.20±0.48
Energy (kcal/100g)	591

Table 2 shows the mineral composition of *M.Falciger*. The sample has high concentrations of potassium (220.4 mg/100g), sodium (118.7mg/100g), magnesium (132mg/100g) and iron (13.56mg/kg), with moderate contents of calcium (81mg/100g), a macro-element, and selenium (22.2 mg/kg), a microelement.

Table.2. Mineral composition of the termites

PARAMETER	SAMPLE COMPOSITION
Sodium (mg/100g)	118.7±0.02
Calcium (mg/100g)	81.0±0.03
Potassium (mg/100g)	220.4±0.06
Zinc (mg/100g)	5.30±0.00
Iron(mg/100g)	18.6±0.4
Magnesium (mg/100g)	132.0±0.00
Manganese (mg/100g)	147.5±0.01
Selenium(mg/100g)	22.2±0.00
Phosphorous (mg/100g)	84.0±0.00

Results of the vitamin analysis (Table 3) of M. Falciger showed that the termite contains relatively low content of vitamin C (17.76 ± 1.79 mg/100g).

Table.3. Vitamin C composition of the termites

PARAMETER	SAMPLE COMPOSITION
Ascorbic Acid (mg/100g)	1.10±0.00

Figure 1 shows the fatty acid profile of *M. Falciger*. Oleic acid (C18:1) was found to be the fatty acid with the highest composition (26.37g/100g) in the sample, while Pentadecanoic acid (C12:0) was the least at 0.09g/100g. The total composition of unsaturated fatty acids was more (60.3%) compared to that of total saturated fatty acid (39.7%).

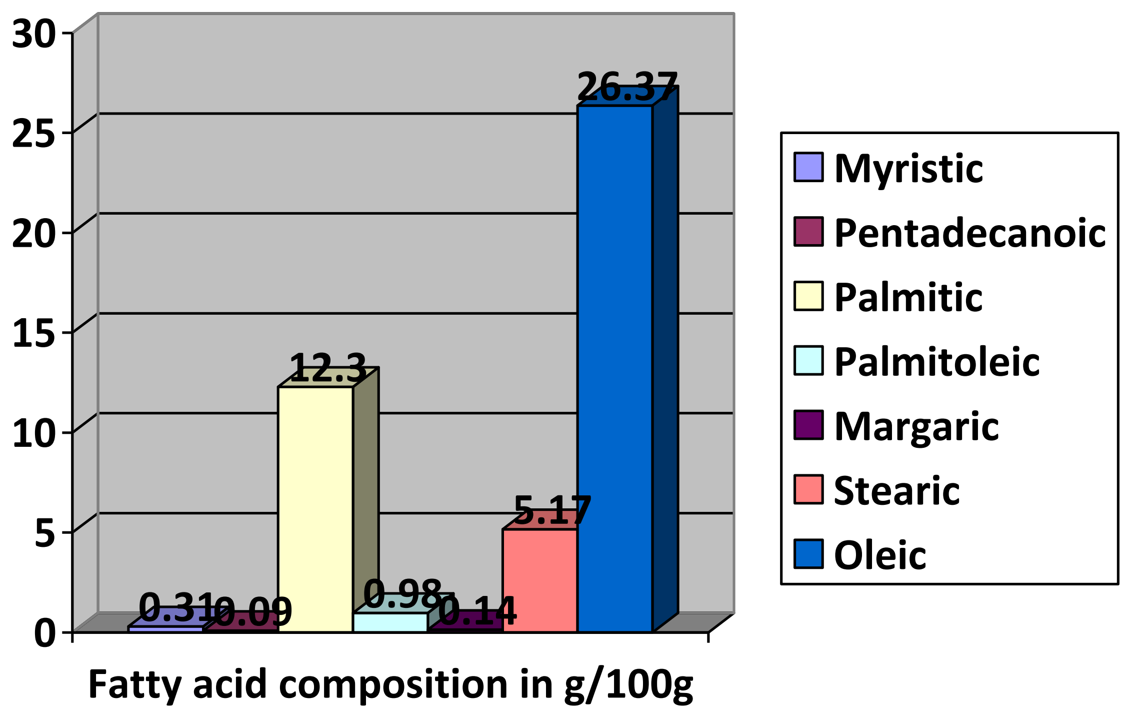

Figure 1 fatty acid composition of the termites

Table 4. % RDA contribution of roasted *M. falciger* to nutrient intake of consumers

PARAMETER	RDA*	*M. falciger*	% RDA Contribution
Energy	2300	591	25.7
Protein	63	23.1	36.7
Calcium	1000	81	8.1
Zinc	15	5.3	35.3
Phosphorous	700	84	12.0

***Source: wardlaw (1999): perspectives in nutrition.**

Table 5.comparison in RDA contribution

PARAMETER	Milk	Soya	*M.falciger*
Energy kcal/100g	0.062	0.446	591
Carbohydrate % RDA contribution	1	10	33.3
Protein % RDA contribution	6	72	36.7
Fat % RDA contribution	1	30	190

Chapter five

5.0 Discussion

In Zambia caterpillars, grasshoppers and winged termites constitute an important part of the diets of the locals. *M. Falciger* is a delicious insect and a highly relished food item in Zambia among the rural populace but is also currently available in most urban markets of the country. The seasons when these insects are available are usually short-lived. However, the processed insects can be stored for 2-3 months, which increases the period of availability for consumption and income generation.

The preliminary results show that this termite is high in protein(23.1 %) and fat(46.5%) with a high energy content of 591 kcal/100g.The ash content is quite low(5.7%) with the major macro-minerals being Potassium ,Sodium and Magnesium and the micro-minerals being zinc, iron, calcium, selenium and manganese. The high content of sodium could be as a result of addition of sodium chloride (NaCl), or table salt during processing.

The crude fat content of the termite is quite high(46.5%) in comparison with the reported mean lipid content of 20% for most adult insects on a dry weight basis as observed by Fast in1970.This is in agreement with the reported oil content of 28.4 % for *M. nigeriensis* by Mbah and Elikima in 2007, 22.5% for M. notalensis as observed by Banjo and colleagues in 2006 ,28.2% for M.bellicossus as reported by Banjo *et al* in 2006) ,36.1% for M.bellicossus as observed by Ekpo and Onigbinde in 2007 and 43.0 for M.falciger as reported by Siulapwa *et al* in 2014) .The fat content is even higher than a lipid value of 46.1% (moisture free basis) earlier reported for *M. bellicosus*, which was at the moment thought to be the highest.(Ukhun and Osasuna,1985) . Dietary fats absorb and retain the flavor of the foods and thus make the food more palatable (Fast, 1970). The high fat content in this termite also contributes to its highly acceptable flavor when fried or roasted, and may contribute to the reduced need of oil in the preparation of its delicacy. Fat is also vital in the structural and biological functioning of cells. However, one implication of the high fat content in the termites is that it may increase chances of insects with high fat content to storage deterioration through lipid oxidation.

The crude protein (23.1%) was higher than the 14.2% reported for *M. subhyalinus* by DeFoliart in 1989 but comparable with 20.4% and 22.1% reported for *M. bellicosus* and *M. notalensis* respectively (Banjo *et al*) and less than the 43.2% reported by Siulapwa and colleagues in 2014. The mean total protein level in the whole samples differed significantly from those of cow milk

(3.8 %), hen's egg (12.4 %) and beef (18.0 %), (FAO, 1972). The daily protein requirement of 23.56 % (NRC, 1974) can be substantially augmented by incorporating processed termite meat into children, pregnant and lactating mother's diets or even adults who are malnourished.

If an adult male of about 70kg body weight requires 35g of protein daily. Only about 113g of the termite food would be required to provide an average adult man's minimum daily protein need, with an allowance of 25% made for indigestibility and the limiting sulphur amino acid content. Therefore, a small amount of this food needs to be consumed per day, especially for children, to meet the requirement.

The computed gross energy value of the sample was 591 kCal/100g. This may go a long way to augmenting the daily energy requirements of 2500 – 3000 kCal recommended for adults (Bingham, 1978) although this amount is closer to what was recommended by FAO (1973), (800 – 1200kCal). No one insect or food source consumed independently as diet can meet the RDA value of 2500 – 3000 kCal. It is therefore reasonable and economical to supplement diets with edible termite or be eaten as dessert, delicacy or appetizer to meet up with the energy demand of the body

The carbohydrate content however is low in comparison with those reported for *M. bellicosus* (43.3%) and *M. notalensis* (42.8%) by Banjo *et al* in 2006 and *M.falciger* as reported by Siulapwa and collegues in 2014. Carbohydrates are important nutritive elements in the human body. They are the main energy source, can reduce consumption of protein and help detoxification. These insect species may not be desirable as a good source of carbohydrate as human adult need about 400 to 500 g carbohydrate intake as starch. The results of this study also showed that the termite had an appreciable content of carbohydrate (16.5%).

The levels of minerals present in the insects indicate that they are good sources of minerals for young, pregnant and lactating mothers. Iron and zinc deficiency are widespread in developing countries, especially in children and women of reproductive age. Iron deficiency leads to anaemia, reduced physical activity and increased maternal morbidity and mortality. Zinc deficiency causes impaired growth and contributes considerably to the high infectious disease burden. The complementary infant feeds could receive a boost with the addition of processed termites to the diets. Minerals are known to play important metabolic and physiologic roles in the living system. Iron, zinc, copper and manganese strengthen the immune system as antioxidant enzyme cofactors Likewise, magnesium; zinc and selenium prevent cardiomyopathy, muscle degeneration, growth retardation, impaired spermatogenesis, immunological dysfunction and bleeding disorders.

The vitamin content of *M. falciger* showed that it contained 1.11 mg/100g of Vitamin C .Vitamin C was on the lower side as compared to what was reported by Igwe et al in 2011 (17.8mg/100g) but comparable to what was found by Adepoju and Omatayo in 2013 (3.6mg/100g) Vitamin C maintains blood vessels flexibility and improves circulation in the arteries of people including smokers. It is also an antioxidant, an oxygen free radical scavenger.

The termites are rich in Oleic acid, Palmitic acid but poor in Myristic acid, Stearic acid, Margaric acid, Pentadecanoic and palmitoleic acid. These observations are in agreement with the reports on *M.bellicosus* (Banjo *et a*l, 2006), and other insect species (Fast, 1970). The total saturated fatty acid content of the termite is 39.7%. Saturated fatty acids are not good for human consumption because they may contribute to atherosclerosis, cancer and aging. Low saturated fatty acid content makes *M.falciger* an important food component for those who have high blood cholesterol content, and may be at risk of cardiovascular disease. However, this may not be the case since over 60% of the fatty acid are unsaturated.

Table 4 shows the possible contribution that M. falciger 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 as shown. Table 5 comparesthe Recommended daily allowance percentages of milk, soyabean and M.falciger.It can be concluded that the edible termites can contribute significant amounts of macronutrients compared to the other to and may thus be suitable to be included in complementary feeds as a means of combating malnutrition..

The only other study done in Zambia is by Silulapwa and colleagues.There are some differences between our study and the above mentioned study in proximate compositions. The termite sample by Chulu et al contains lipid (46.5 ± 0.01%), protein (23.1%) ,carbohydrate (16.5 ± 0.00%) and Energy content of 591kcal/100g compared to lipid (43±0.3),protein (43.3±0.03),carbohydrate (32.8±0.6) and Energy 810.2kcal/100g as found by Siulapwa and colleagues. These variations could be attributed to the different ecotypes and age of insects among other factors

Chapter six

6.0 Conclusion

In conclusion, the study has revealed *M. falciger* as a very good source of nutrients, vitamins, minerals and unsaturated fatty acids, especially proteins and carbohydrate necessary for combating protein energy malnutrition rampant in our world today. Given the observed high lipids, protein and carbohydrate contents of this termite, it could be inferred that the delicacy, if adequately promoted, can help in controlling protein energy malnutrition, an imbalance between the supply of protein and energy, and the body's demand for them to ensure optimal growth and function, which is currently ravaging children in developing countries. Thus, edible termites can supply necessary nutritive elements for human body functions and could be consumed along with other food and animals rich in other essential minerals to further complement the diet of these insects. The recommendation would be to explore the toxicological properties of this edible termite, to see ways of coming up with an infant complementary food that could be added to other foods in order to prevent malnutrition and to do nutritional analysis of these termites from various regions of the country in order to see the variations in content and how this influencs the Recommended Daily Allowances. .

Chapter Seven

7.0 References

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Chapter Eight

8.0. Appendices

8.1. Data collection tables.

1. Proximate analysis

Parameter	Sample1	Sample 2	Sample 3	mean	SD
Moisture					
Crude Protein					
Crude Fat					
Ash					
Crude Fibre					
Carbohydrates					
Gross energy (Kcal)					

2. Mineral analysis

Parameter	Sample 1	Sample 2	Sample 3	mean	SD
potassium					
Sodium					
Calcium					
Magnesium					
Iron					
Phosphorus					
Zinc 1					
Manganese					
Selenium					

3. Vitamin analysis

PARAMETER	SAMPLE 1	SAMPLE 2	SAMPLE 3	MEAN	SD
Ascorbic acid					

4 .Fatty acid analysis

Parameter	**SAMPLE1**	**SAMPLE 2**	**SAMPLE 3**	**MEAN**	**SD**
Mystiric acid (C14:0)					
Pentadecanoic acid (C15:0)					
Palmitic acid (C16:0)					
Palmitoleic acid (C16:1)					
Margaric acid (C17:0)					
Stearic acid (C18:0)					
Oleic acid (C18:1)					

8.2 Ghant Chart

Activity	April, may,2014	June,2014	July ,August,2014	September,2014-March,2015	April,2015	May,2015
Idea submission						
Proposal writing and presentation						
Submission to ethics committee						
Data collection						
Data analysis						
Final report submission						

8.3 Budget

Item	Quantity required	Unit Cost (ZMKR)	Total Cost (ZMKR)
Typing Paper	1	35	35
Notebook	1	10	10
Pens	10	1	10
USB mass storage disk	1	200	200
Computer	1	5000	5000
Printer	1	600	600
Ink cartridges	1	350	350
Hiring of laboratory facility local	1 unit	3900	3900
Hiring of laboratory facility abroad	1 unit	5000	5000
Data form	20	0.5	10
ERES	1	1000	1000
Transport			2000
Contingency			2000
TOTAL			**20115**