Effects of *Macrotermes nigeriensis* Based Diet on Hepatic and Serum Lipids of Albino Rats

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Abstract: Twenty male albino rats of about 6 weeks old randomly distributed into 4 groups were respectively fed growers’ mash as the control diet, and 25%, 50% and 75% oven-dried, ground *Macrotermes nigeriensis* supplemented diets for 28 days. Plasma and hepatic triacylglycerol, total cholesterol, HDL-cholesterol and free cholesterol concentrations were measured spectrophotometrically. The values of esterified cholesterol and LDL-cholesterol as well as the positive and negative atherogenic risk predictor indices were calculated. The animals on the supplemented diet did not gain more weight than the control group. There were significant (p<0.05) increases in hepatic total and free cholesterol concentrations with increased dosage of *M. nigeriensis*. Similarly, plasma total cholesterol and HDL-cholesterol significantly (p<0.05) increased with higher supplementation. On the other hand, hepatic and plasma triacylglycerol concentrations were only significantly (p<0.05) increased upon supplementation with up to 75% *M. nigeriensis*. Interestingly, both the positive and negative atherogenic risk predictor indices were not significantly (p>0.05) affected by the diets. Moderate diet supplementation with *M. nigeriensis* may be recommended for maintenance of body lipid concentrations, and as a possible replacement for the commonly available saturated animal fats.

Key words: *Macrotermes* spp, cholesterol, fatty acids, atherogenic index, triacylglycerol.

INTRODUCTION

Insects are an important food source for humans. There are more than 400 known species of edible insects worldwide, including the seasonally available African termites. In Africa, over 250 species of insects have been used as traditional foods among indigenous people and have played an important role in the history of human diet. They are rich in protein, vitamins and minerals, and a good source of iron and B-vitamins (van Huis, 2003). Whether or not insects are eaten depends not only on taste and nutritional value, but also on customs, ethnic preferences or prohibitions. Furthermore, interest in the consumption of insects in Africa has been seriously affected by the unsung “Europeanization” of taste and diet among many Africans including the poor, notwithstanding the dwindling availability of quality food supply in Africa.

Termites are a popular human food that provides protein and energy when other foods are scarce. In some regions of Africa, termites are a delicacy eaten only by tribal chiefs (Logan, 1992). Women and children in Nigeria collect winged reproductives and queens of *Macrotermes* species for eating by all age groups (Fasoranti and Ajiboye, 1993). In Bouake, Cote d’Ivoire, hordes of people are commonly seen frantically catching swarming termites under street lights after the first rains of the rainy season (Heinrichs and Barrion, 2004). *Macrotermes nigeriensis* is a winged adult termite of the order, Isoptera and family, termitidae. Although, *M. nigeriensis* is an eusocial insect with a typical colony containing nymphs (semi-mature young), workers, soldiers and the reproductive individuals (alates) of both genders, it is the alates that are commonly caught and consumed. The alates are the final and fully developed adult stage of the termites, among which are also fair variations, perhaps due to geographical locations or developmental stages. This has made many authorities to adopt names such as *M. nigeriensis*, *M. notalensis*, *M. subhylinus* or *M. belicosus*. Many researches, however, settle for ‘termites’, ‘winged termites’ or ‘*Macrotermes* species’ to avoid confusion (Banjo et al, 2004; Mbah and Elekima, 2007). They are known locally in various parts of Nigeria by different names: aku (Ibo), chinge (Hausa) and Esusu (Yoruba). *M. nigeriensis* is enjoyed in all parts of the country, especially because they are present at the beginning of the rainy season when livestock is lean, new crops have not yet produced food, and store produced from previous growing season is running low.
At the onset of rainy season, the winged reproductives fly off from their nest in large numbers. During this nuptial flight, pairs of male and female alates isolate themselves from the others and fall to the ground. Their wings break off and each pair goes its own way to form a nest in a suitable spot, where they become the potential king and queen. During the flight, they are usually attracted to sources of illumination and are thus harvested by placing a bowl of water under a light source. In most parts of Nigeria, *M. nigeriensis* is sold in open market after being well prepared by washing, salting to taste and mild frying. It can also be consumed raw. It has a nutty flavor when prepared. Oil is not usually needed during frying, since their bodies are naturally rich in oil. They have been reported to be nutritious and a good source of protein for man and animals. In fish farming, they have been tested as an alternative feedstuff to the *Heterobranchus longifilis*, which is a major mud catfish species in Nigeria that inhabits fresh water bodies (Reed *et al*, 1967).

Notwithstanding the popularity of *M. nigeriensis* as a delicacy in Nigeria, not much work has been done on the nutritional benefits derivable from its consumption. The present study was undertaken to provide data on the effects of its consumption on hepatic and serum lipid and lipoprotein profiles of albino rats.

**MATERIALS AND METHODS**

**Animals:**

Twenty male albino rats of mean weight 80.0 ± 6.3g, and about 6 weeks old obtained locally from Nsukka, Enugu State, Nigeria were housed in metal cages. They were fed growers mash (Grand Cereals and Oil Mills, Nigeria) and supplied water *ad libitum* for about two weeks to acclimatize them to laboratory conditions. They were later distributed randomly into 4 groups (A-D) of 5 rats each, and housed in 4 different metal cages. The control animals (group A) were fed the growers’ mash, while groups B-D were fed 25%, 50% and 75% of *Macrotermes nigeriensis* supplemented diets respectively.

**Processing of Macrotermes nigeriensis Diet:**

The alates of *M. nigeriensis* were collected in the early morning hours of July 2010, from residential buildings in and around Federal University of Technology, Owerri, Nigeria. They were washed, oven-dried at 40°C to a constant weight, and ground into coarse pellets of similar sizes with the control diet. And then used with the growers’ mash for compounding of the various *M.nigeriensis* based diets.

**Sample Collection and Analysis:**

The experimental feeding period lasted for 28 days. During the period, the rats’ body weight changes were measured and recorded every 7 days. At the end of the 28 days, the animals were fasted overnight and anaesthetized with chloroform. Then, about 5ml of blood was collected from each animal by cardiac puncture. This was carefully dispensed into anticoagulant (lithium heparin) sample bottle, mixed, centrifuged and plasma separated. The plasma obtained was used for enzymatic determination of plasma total cholesterol (TC), triacylglycerol (TG) and high-density lipoprotein cholesterol (HDL-C) with the aid of kits supplied by Quimica Clinica Aplicada, Spain (Walmsley and White, 1994). Low-density lipoprotein cholesterol (LDL-C) was estimated using the friedewald formula (Friedewald *et al*, 1972). The positive and negative atherogenic risk predictor indices were also calculated (Ojiako and Nwanjo, 2009).

Immediately after blood collection, each of the animal was sacrificed while still unconscious, and the liver removed. Three grams (3g) of the liver sample were ground and then washed into 24 ml of chloroform-methanol mixture (2:1 ratio) in a tube. The tube was corked, mixed vigorously by shaking and allowed to stand overnight. The homogenate solution was later filtered. To the filtrate, an equal volume of 1% NaCl solution was added and mixed thoroughly. The lower lipid extract layer was then separated and used for hepatic total and free cholesterol, and triacylglycerol determinations (Igwe *et al*, 2006). Triacylglycerol concentration was determined with the aid of kits supplied by Quimica Clinica Aplicada, Spain (Walmsley and White, 1994). While, the hepatic total and free cholesterol concentrations were determined spectrophotometrically by the method of Abell-Kendall (Abell *et al*, 1952). Esterified cholesterol concentrations were obtained by subtracting the free from the total cholesterol (Igwe *et al*, 2006).

**Statistical Analysis:**

Statistical analysis was by the use of one-way ANOVA. Values for *p*<0.05 were considered statistically significant.
Results:

The control animals (group A) showed a higher weight gain (145.00 ± 10.00g) than the experimental animals; group B (140.00 ± 37.41g), group C (120.00 ± 16.33g) and group D (130.00 ± 11.55g). However, the differences in weight gained by the various groups of animals were not statistically significant (p>0.05; Figure 1).

There were significant (p<0.05) increases in plasma total and HDL cholesterol concentrations in all the experimental groups in comparison with the control group (Table 1). The increases observed were progressive with increased percentage *M. nigeriensis* supplementation. Similarly, the concentration of plasma LDL-cholesterol increased, but non-significantly, with higher dosage of *M. nigeriensis*.

Hepatic total cholesterol concentration was significantly (p<0.05) reduced in the 25% *M. nigeriensis* fed animals (group B), but increased significantly (p<0.05), along with free cholesterol concentrations, in the animals fed 50% (group C) and 75% (group D) of the supplemented diet (Table 2). Esterified cholesterol concentration was significantly (p<0.05) reduced by the administration of the *M. nigeriensis* based diet. The level of reduction in the esterified cholesterol concentration, however, narrowed with increase in the percentage supplementation, to achieve a non-significant (p>0.05) change at 75% level of supplementation.

Both plasma and hepatic triacylglycerol concentrations were not significantly (p>0.05) increased by the administration of the 25% and 50% *M. nigeriensis* based diets. However, increased supplementation to 75% elicited a significant (p<0.05) increased plasma triacylglycerol concentration, with a concomitant reduction (p<0.05) in hepatic triacylglycerol.

Table 3 shows that diet supplementation at the different dosages used did not significantly (p>0.05) alter neither the positive nor the negative atherogenic risk predictor indices. However, there was noted a gradual but non-significant increase in the negative predictor index with increase in *M. nigeriensis* supplementation.

![Fig. 1: Change in body weights of the rats fed the different experimental diets.](image)

Table 1: Plasma cholesterol and triacylglycerol concentrations (mmol/l) of the different groups.

<table>
<thead>
<tr>
<th>Parameter (mmol/l)</th>
<th>Control (Group A)</th>
<th>25% MN (Group B)</th>
<th>50% MN (Group C)</th>
<th>75% MN (Group D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cholesterol</td>
<td>2.45 ± 0.33a</td>
<td>3.34 ± 0.96b</td>
<td>3.47 ± 0.56b</td>
<td>4.07 ± 0.71a</td>
</tr>
<tr>
<td>HDL-Cholesterol</td>
<td>1.26 ± 0.05a</td>
<td>1.63 ± 0.15b</td>
<td>1.73 ± 0.33b</td>
<td>1.70 ± 0.48b</td>
</tr>
<tr>
<td>LDL-Cholesterol</td>
<td>0.84 ± 0.34a</td>
<td>1.31 ± 0.69b</td>
<td>1.33 ± 0.34a</td>
<td>1.66 ± 0.61a</td>
</tr>
<tr>
<td>Triacylglycerol</td>
<td>0.64 ± 0.05a</td>
<td>0.91 ± 0.48b</td>
<td>0.93 ± 0.20a</td>
<td>1.56 ± 0.11b</td>
</tr>
</tbody>
</table>

Values are mean ± standard deviation. Values with different alphabets per row are statistically significant (p<0.05). MN = *Macrotermes nigeriensis*.

Table 2: Hepatic cholesterol and triacylglycerol concentrations (mg/g wet tissue) of the different groups.

<table>
<thead>
<tr>
<th>Parameter (mg/g tissue)</th>
<th>Control (Group A)</th>
<th>25% MN (Group B)</th>
<th>50% MN (Group C)</th>
<th>75% MN (Group D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cholesterol</td>
<td>3.49 ± 0.31a</td>
<td>2.78 ± 0.29a</td>
<td>4.43 ± 0.65a</td>
<td>4.51 ± 0.20a</td>
</tr>
<tr>
<td>Free Cholesterol</td>
<td>1.03 ± 0.11a</td>
<td>1.53 ± 0.17a</td>
<td>2.38 ± 0.30a</td>
<td>2.02 ± 0.21a</td>
</tr>
<tr>
<td>Esterified Cholesterol</td>
<td>2.47 ± 0.21a</td>
<td>1.25 ± 0.15a</td>
<td>2.05 ± 0.36a</td>
<td>2.49 ± 0.21a</td>
</tr>
<tr>
<td>Triacylglycerol</td>
<td>2.06 ± 0.10a</td>
<td>2.07 ± 0.11b</td>
<td>2.09 ± 0.12a</td>
<td>1.64 ± 0.12b</td>
</tr>
</tbody>
</table>

Values are mean ± standard deviation. Values with different alphabets per row are statistically significant (p<0.05). MN = *Macrotermes nigeriensis*.  

908
Table 3: The positive and negative atherogenic risk predictor indices of the different groups.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control (Group A)</th>
<th>25% MN (Group B)</th>
<th>50% MN (Group C)</th>
<th>75% MN (Group D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive index (HDL-C/TC)</td>
<td>0.52 ± 0.10a</td>
<td>0.52 ± 0.13a</td>
<td>0.50 ± 0.07a</td>
<td>0.50 ± 0.15a</td>
</tr>
<tr>
<td>Negative index (LDL-C/HDL-C)</td>
<td>0.67 ± 0.28a</td>
<td>0.78 ± 0.39a</td>
<td>0.79 ± 0.26a</td>
<td>1.07 ± 0.50a</td>
</tr>
</tbody>
</table>

Values are mean ± standard deviation. Values with different alphabets per row are statistically significant (p<0.05). MN = Macrotermes nigeriensis.

Discussion:

Macrotermes nigeriensis is a highly relished delicacy among all age groups in Africa. It is usually attracted to sources of light at nights and during early hours of the morning. The usual steps involved in its processing included de-winging, salting and frying or roasting. It is seasonally available in open markets for use as a snack eaten alone or in combination with other food items. It has high percentage protein and oil content (Mbah and Elekima, 2007; Ekpo and Onigbinde, 2007).

Data from this investigation shows that the body weight gain by all the animals fed with the respective M. nigeriensis based diets were not significantly different to the weight gains in the age-matched control group. Interestingly, the animals fed the termite diets gained lesser weights than the control animals. This indicates that, although the termite diet is rich in fats and oil (Mbah and Elekima, 2007), the consumer might not be prone to excessive and abnormal weight gain, which might lead to obesity and its associated disease conditions. The lest weight gain was observed among the animals fed the 50% termite diet indicating a good balancing of the individual effects of the control diet alone (group A), a high termite diet (75%; group D), and a fairly high control (75%) plus low termite (25%) based diet (Group C). This presents the advantage accruable from intake of the termite in combination with other food item. A practice common to the indigenous consumers of this delicacy in Nigeria.

The termite-based diet caused significant (p<0.05) dose-dependent increases in both plasma total cholesterol and HDL-cholesterol concentrations. Similarly, there were significant (p<0.05) increases in the hepatic total and free cholesterol concentrations with increase in the termite percentage diet supplementation. The dose-dependent increase observed in both plasma and hepatic total and free cholesterol concentrations may be attributed to the high oil content (28.37%) of the termite (Mbah and Elekima, 2007). The unsaponifiable fraction of this oil has been reported to be as high as 12.04%, with one-third of it being sterol of which 85% was cholesterol (Bergmann, 1937; Ekpo and Onigbinde, 2007). Similarly, the total and free cholesterol values for the termite’s oil were reported as 8.73 and 41.80 mg/100g lipid respectively. The high sterol value of the termite may explain the observed high serum and hepatic total and free cholesterol concentrations. Studies have indicated that high blood cholesterol concentrations are strongly related to coronary atherosclerosis and increased risk of cardiovascular diseases (Treasure et al, 1995). However, clinical studies have also shown that lowering cholesterol concentrations, either by the use of diet or drugs, decreases the incidence of coronary heart disease (Steiner and Li, 2000; Oze et al, 2008).

The results of this showed that the animals may have responded to the high dosage of sterol and a concomitant increase in body total and free cholesterol concentrations by a gradual but significant increase in HDL-C concentration. HDL has been reported to remove cholesterol from circulation and atheroma within arteries, and transport same back to the liver for excretion or re-utilization (Kwiterovich, 2000). This may have also resulted in the observed increase in hepatic esterified cholesterol concentration from a significantly lower value (1.25 ± 0.15mg/g tissue), when compared with that of the control (2.47 ± 0.21 mg/g wet tissue), to a higher but non-significant value of 2.49 ± 0.21 mg/g wet tissue. Absorbed free cholesterol in the body is solely esterified by the hepatocytes.

LDL-C concentration was not significantly (p>0.05) increased by the administration of the termite-based diets. LDL transports cholesterol through the arteries, where they can be retained by arterial proteoglycans, starting plaque formation. LDL becomes atherogenic when it is modified by oxidative reactions. Since the oxidized form of LDL is easily retained by the proteoglycans, increased levels of LDL-C have been associated with atherosclerosis, heart attack, stroke and peripheral vascular disease (Cromwell and Otvos, 2004). Thus, the observed potential of the termite-based diet to significantly improve HDL-cholesterol concentration, with a concomitant non-significant effect on LDL-C concentration, indicates a potential for reduction in cardiovascular risk in its consumers. Calculation of the ratio of the mean concentrations of HDL-C to LDL-C (that is, ‘good’ cholesterol versus ‘bad’ cholesterol) gave values of 1.24, 1.30 and 1.02 for the 25%, 50% and 75% termite diets respectively. This indicates that consumption of diets supplemented with more than 50% of M. nigeriensis may not have much health advantage.
This point is further buttressed by the earlier observed least weight gain among the animals fed the 50% termite-based diet. In addition to this, is the observed significant (p>0.05) increase in plasma triacylglycerol concentration of (only) the group fed the 75% termite-based diet. Increase in plasma triacylglycerol, cholesterol and LDL-C concentrations have been implicated in atherogenicity (Igwe et al, 2007).

Meanwhile, a study of the effects of the termite-based diets on both positive and negative atherogenic risk predictors indices showed no significant (p>0.05) changes. However, it is worthy of note that the 75% termite based diet did not affect the positive atherogenic index, but increased the negative atherogenic risk index by about 40% over that of the control diet.

Thus, it is concluded that consumption of *M. nigeriensis* based diet does not have detrimental effect on lipid and lipoprotein profiles of albino rats. It significantly increased HDL-C concentration and thus, may not constitute cardiovascular risk for consumers. However, the termite-based snack or food must be consumed with moderation, not exceeding 50% of total daily food intake.

REFERENCES


