**IMPACT OF PROCESSING TEMPERATURE AND TIME VARIABILITY ON NUTRIENTAND OIL PROFILE OF EDIBLE AFRICAN TERMITES (***MACROTERMES NIGERIENSIS)*

**ABSTRACT**

**Background and Objective:** The edible winged African termite (Macrotermes nigeriensis) is an adult termite with wings that belongs to the Isoptera order and T*ermitidae* family. Most Nigerians have direct or indirect experience with the practice of eating edible insect due to their high protein, fat, minerals and vitamins content. This research work was aimed at examining the impact of processing temperature and time variability on the nutrient and oil profile of edible winged African termites, *Macrotermes nigeriensis.*

**Materials and Method:** the impact of processing temperature and time variability on the nutrient and oil profile of edible winged African termites was evaluated for proximate, minerals, amino acid and fatty acid using standard and spectroscopic methods.

**Result:**  The result gotten from edible winged African termites oven dried at different processing temperatures and time (50oC for 6h, 12h and 18h) (75oC for 6h, 12h and 18h) and (100°C for 6h, 12h and 18h) showed that crude protein (34.67 – 39.83%), fat (34.12 – 37.73%), ash content (2.56 – 4.89%) and energy value (518.74 – 543.05Kcal/100g) were significantly increased at higher temperature and increase time. The moisture (4.65 – 8.79%) and carbohydrate content (11.04 – 18.25%) decreased with higher temperature and increase time.Similarly, the mineral content was also increased at higher processing temperature (100oC) for shorter time (6h). The amino acid was significantly higher in samples oven dried at 75oC and 100oC for 6h, Leucine (7.47mg/100g), Lysine (6.91mg/100g), Isoleucine (4.94mg/100g), Phenylalanine (4.57mg/100g), The identified fatty acids present included palmitoleic acid (0.24 - 53.24%), palmitic acid (0.25 - 14.32%), Oleic acid (1.48 - 49.7%), vaccenic acid, n- Hexadecanoic acid, 6- octadecenoic acid, and other were significantly influenced by processing temperature and time.

**1. INTRODUCTION**

Edible insects have long provided Africans, Asians, Australians, and Latin Americans with traditional and nutritionally significant food (Allotey and Mpuchane 2003). They contain a lot of protein, calories, and other vitamins and minerals (Allotey and Mpuchane, 2003; Igwe *et al*., 2011). Entomophagy, the practice of eating insects is a customary practice in the world by more than two billion people (van Huis 2013). According to Rumpold and Schlüter (2013) and Nowak *et al.* (2016), edible insects are high in protein, fat, minerals and vitamins. Eating of insects has been linked to significant amounts of high-quality, easily digestible proteins, according to numerous studies (Ekpo *et al.,* 2009). Studies have shown that most Nigerians have had direct or indirect experience with entomophagy, although it is more prevalent in the rural than urbanized areas. It unquestionably contributed significantly to the decline of Kwashiorkor among young children of low-income parents. However, it still persists and continues to play key roles in the lives of people in poor places, despite the fact that entomophagy has considerably declined with the development of modern agriculture.

The winged termites go by a variety of names regionally in different parts of Nigeria, including "aku" in Ibo, "chinge" in Hausa, and "Esusu" in Yoruba. Every region of Nigeria enjoys *Microterme nigeriensis*, especially towards the beginning of the rainy season when animals are thin, fresh crops haven't yet generated food, and supplies from the previous growing season are running low. Edible insects are generally abundant, nutrient-dense, and economically valuable. They constitute an important part of the daily diet of a large population worldwide either as a snack or as a meal (Ayieko *et al.,* 2010). One potential limiting factor in the use of insects as a nutritional intervention food is the high degree of variability seen in the nutritional content of insects, even within the same species (Ramos-Elorduy *et al.,* 2002). It is well established that food processing, particularly using heat, can affect bioavailability of minerals and cause nutritional degradation of many foods (Dobermann *et al*., 2019)

The study examined the impact of processing temperature and time variability on the nutrient and oil profile of edible winged African termites (*Macrotermes nigeriensis)* because insects bred for food are not processed in a uniform manner.

**2. MATERIALS AND METHODS**

**2.1 Study Area:** The study was carried out at Food Science and Technology Department; Food Chemistry Laboratory; Michael Okpara Univertsity of Agriculture, Umudike. Biochemistry Laboratory of National Root Crop and Research Instistute (NRCRI) and Biochemistry laboratory

**2.2 Sample Collection and Identification:** The edible winged African termite *(Macrotermes nigeriensis)* was collected at the beginning of the rainy season between June and July, 2023 from Ibiaku Ikot Ukpong village in Ibiono Ibom LGA, Akwa Ibom State. The harvested edible winged termite where identified at the Entomology Division of the Department of Zoology and Environmental Biology, Michael Okpara Univertsity of Agriculture, Umudike as *Macrotermes nigeriensis*

**2.3 Methods**

**2.3.1 Proximate determination**

The moisture content of the oven dried edible winged African termite (*Macrotermes nigeriensis)* samples expressed as a percentage was determined by the standard methods described by AOAC (2006), Ash content by AOAC (2006), crude fat by AOAC (2006), crude fibre by AOAC (2006), crude protein content by AOAC (2006) and the carbohydrate content was obtained by difference.

**2.3.2 Mineral Analysis**

The mineral content of the African termite samples was determined by the dry ash extraction method described by Carpenter and Hendricks (2003).

**2.3.3 Amino Acid analysis**

The Amino Acid profile was determined using the method described by AOAC (2005) with modifications. Applied Biosystems PTH Amino Acid Analyzer was used to determine the different amino acid composition of the edible African termite samples**.**

**2.3.4 Fatty Acids Determination**

The extracted oil sample from edible African termites was subjected to fatty acid determination which was based on the methods described by Adepoju *et al.,* (2014) using Gas Chromatography-Mass Spectrometry (GC-MS-QP 2010 plus Shimadzu, Japan).

**2.4 Experimental design**

The study was carried out using a two factor (3x3) factorial design, with the two factors A and B being the drying temperature and drying time, respectively. The three levels of factor A, drying temperature were 500C, 750C and 1000C, while factor B, drying time had 6h, 12h and 18h as the levels.

**2.5 Statistical analysis**

The result (data) obtained where analyzed using two way analysis of variance (ANOVA) to test for significant differences at 5% probability (p<0.05). Minitab statistical package version 18 was used for data analysis and significant mean differences were separated using the Fisher’s least significant (FLSD) test.

**3. RESULT AND DISCUSSION**

**3.1 Proximate Composition**

The result of proximate composition of the oven dried edible winged African termites is presented in table 1 for moisture, crude protein, fat, crude fibre, ash and carbohydrate content.

**3.1.1 Moisture content**

The moisture content of the oven dried edible winged African termite ranged from 4.65% to 8.79% as shown on Table 1 below. Drying at constant 6 hr, at 50oC (8.79%), 75oC (7.16%) and 100oC (6.06%). drying for 12 hr, at 50oC (8.07%), 75oC (6.86%) and 100oC (5.52%). Drying at constant 18 hr, at 50oC (7.89%), 75oC (6.69%) and 100oC (4.65%). There was a significant (P<0.05) decrease in the trend which also support that time has a significant (p<0.05) effect in reducing the moisture content of the termite. The moisture content of termites significantly decreased (p < 0.05) with both increasing drying time and temperature, indicating that temperature had a stronger influence on moisture reduction.

At a constant temperature of 50°C, moisture content declined gradually from 8.79% (6 hr) to 7.89% (18 hr). At 75°C, it decreased more sharply from 7.16% to 6.69%, and at 100°C, the reduction was most pronounced, from 6.06% to 4.65% over the same time span. This shows that higher temperatures accelerate drying efficiency, likely due to faster evaporation of water.

Similarly, when holding time constant, increasing the temperature from 50°C to 100°C led to a consistent decline in moisture content at each time point: 6 hr: 8.79% to 6.06%, 12 hr: 8.07% to 5.52% and 18 hr: 7.89% to 4.65%. This pattern confirms that temperature is a key factor in reducing moisture content, and that extended drying time further supports moisture loss, though with diminishing returns. Efficient drying of termites is best achieved at higher temperatures for longer durations, without compromising quality through over processing. The moisture content obtained were lower compared to that obtained by Igwe *et al*. (2011) who reported oven dried (400C) edible winged African termite as 10.78%. The relatively low moisture content of edible winged African termites enables it to be stored for longer periods, especially during the dry season when food shortage is higher (Jonathan, 2012). The optimal moisture content of the oven dried edible winged termites was obtained at 100oC for 18 h. The moisture content of food materials is of significance to shelf life, packaging and general acceptability (Okaka and Okaka, 2001).

**3.2 Crude protein**

The crude protein content of the oven dried edible winged African termite ranged from 34.67% to 39.83% as shown on Table 1 below. At constant temperature 50oC, samples processed for 6 hr had 34.67%, 12 hr had 35.49% and 18 hr had 36.53%. At constant 75oC, samples processed for 6 hr had 37.08%, 12 hr had 37.96% and 18 hr had 38.25%. At constant 100oC, samples processed for 6 hr had 6.06%, 12 hr had 5.52% and 18 hr had 4.65%. There was a significantly (p<0.05) increase in crude protein content which showed that temperature has a significantly (p<0.05) effect on the protein content of the termite. Higher temperatures likely caused better **moisture loss** (dehydration). Thereby concentrating the protein relative to the termites dries mass.
Also**, heat treatment can break down complex protein structures,** making the protein more detectable during analysis (e.g., by increasing solubility or denaturing proteins). This explains why higher temperatures consistently led to higher protein percentages.

At constant time 6 hr, at 50oC (34.67%), 75oC (37.08%) and 100oC (39.83%). processed for 12hr, at 50oC (35.49%), 75oC (37.96%) and 100oC (39.49%). processed at constant 18 hr, at 50oC (36.53%), 75oC (38.25%) and 100oC (39.14%).

There was a significant (P<0.05) increase in the crude protein content of the edible termite with a significant effect on the longer processing times allow for gradual moisture evaporation, slightly increasing the protein concentration. However, beyond a certain point (especially at high temperatures like 100°C), prolonged heat exposure may start degrading some proteins through reactions such as Maillard browning or thermal denaturation, leading to a slight reduction in measurable crude protein after 18 hours. Thus, while time has a positive effect initially, excessive duration at high temperatures could slightly damage or alter proteins, reducing the final crude protein content.

This finding was in agreement with the findings of Fombong and Kinyuru (2018) who reported protein content of African termite to be of the range 34.67% to 39.83% and Dobermann *et al.* (2019) who reported that there was a significant difference in protein content of black cricket samples which were oven dried at temperature of 450C and 1200C. The crude protein content of edible winged African termites was lower compared to palm weevil total protein content of 66.30% (Elemo *et al.,* 2011.; Okunowo *et al.,* 2017). It could be expected here that the high protein content found in the edible African termites could help to tackle the problem of protein deficiency and to reduce malnutrition, if regularly consumed.

**3.3 Crude fat content**

The fat content of the oven dried edible winged African termites ranged from 34.12% to 37.73% as shown on table 1 below. There was a significant increase (P<0.05) in the fat content of the termites which increased progressively with both **temperature** and **processing time,** though the impact of **temperature** was more pronounced than that of time. At a constant time of 6 hours, fat content rose from 34.12% at 50°C to 36.43% at 100°C, indicating that higher temperatures enhance fat retention or concentration, likely due to more efficient moisture loss leading to a higher proportion of fat in the dry matter.

Similarly, at 12 hours, fat content increased from 34.52% (50°C) to 37.03% (100°C), and at 18 hours, from 35.03% to 37.73%, showing a consistent temperature-driven trend. When temperature was held constant, fat content also gradually increased with time, though the changes were more modest: At 50°C: from 34.12% (6 hr) to 35.03% (18 hr), At 75°C: from 35.20% to 36.62% and At 100°C: from 36.43% to 37.73% This suggests that while longer drying times allow more water loss, the main driver of fat concentration is the processing temperature, which may improve fat extractability or reduce oxidation at optimal levels. Overall, drying at higher temperatures for longer times enhances the measurable fat content of termites, with 100°C for 18 hours yielding the highest fat content (37.73%).

 The fat content obtained corroborate with the reports of earlier researchers, Igwe *et al.* (2011) who oven dried edible winged African termite at 400C to a constant weight reported fat content to be 34.23% and Kinyuru *et al*. (2010) who reported 39.0g/100g to fat content of the edible winged Termite toasted at 1500C for 5min and dried at 300C.

The result shows that the processing method (oven drying), temperature and time had effect on the fat content of the sample. We can deduce that regular consumption of edible African termite could be a good source of rich fat which play the role of providing the human body with energy, absorbs certain nutrients and maintain body temperature.

**3.4 Crude fibre content**

Table 1 below shows that the crude fibre content of the edible winged African termite oven dried at different temperature and time had a significant increase (P<0.05) in the crude fibre content which ranged from 1.63% to 2.14%. This trend highlights the role of thermal processing in influencing fibre concentration and composition.

Effect of temperature (at Constant Time) at all fixed time points (6, 12, and 18 hours), increasing the drying temperature from 50°C to 75°C led to a noticeable increase in crude fibre: 6 hr: 1.63% (50°C) to 2.03% (75°C) to 1.72% (100°C), 12 hr: 1.67% to 2.09% to 1.78% and 18 hr: 1.73% to 2.14% to 1.87%. The peak fibre content was consistently observed at 75°C, while a slight drop occurred at 100°C. This suggests that moderate heat (75°C) enhances fibre concentration more effectively than higher temperatures. The likely reason is that excessive heat (100°C) may start degrading or altering some fibre components (such as hemicellulose), resulting in lower measurable fibre content.

Effect of time (at constant temperature) across all temperatures, extending the drying time from 6 to 18 hours also increased crude fibre content: 50°C: 1.63% (6 hr) to 1.73% (18 hr), 75°C: 2.03% to 2.14% and 100°C: 1.72% to 1.87%

This steady increase indicates that longer drying times allow for more complete moisture removal, thus concentrating the remaining components like fibre. Additionally, extended drying may reduce soluble constituents, indirectly increasing the relative fibre percentage in the sample. The result obtained was lower compared to the findings of Hlongwane *et al.* (2020) on African termite had 5.5% crude fibre and also lower to 5.71% from Igwe *et al.* (2011) findings on the crude fibre content of the toasted edible termite

The significant rise in crude fibre with both temperature and time reflects **moisture loss,** **structural concentration,** and possibly **thermal modification of** fibrous materials. The **optimal fibre levels** were achieved at **75°C for 18 hours (2.14%),** likely balancing effective drying without degrading heat-sensitive fibre components. These results suggest that **moderate drying conditions** are ideal for maximizing crude fibre retention in termites. Fibre offers a variety of health benefits and is essential in reducing the risk of chronic disease such as diabetes, obesity, cardiovascular disease and diverticulitis. Fibre acts to lower the concentration of low density lipoprotein cholesterol in the blood, possibly by binding with bile’s acids. It also helps to eliminate waste from the gastrointestinal tract because of its ability to bind water and thus soften the stool (Farinde *et al.,* 2018).

**3.5 Ash content**

Table 1 below showed the ash content of the edible African termites. The ash content of the edible African termites significantly (p<0.05) increased with both rising temperature and longer drying time, ranging from 2.56% to 4.89%. This trend indicates a concentration effect due to moisture loss during oven drying.

Effect of temperature (at constant time) At each constant time (6, 12, and 18 hours), ash content rose steadily with temperature: 6 hr: 2.56% (50°C) to 4.55% (100°C),12 hr: 2.85% to 4.72% and18 hr: 2.96% to 4.89%This suggests that higher temperatures enhance moisture evaporation, leaving a higher proportion of mineral residues, which are reflected as ash content.

Effect of time (at constant temperature): Similarly, at each fixed temperature, ash content increased with time: 50°C: 2.56% (6 hr) to 2.96% (18 hr), 75°C: 3.44% to 3.78% 100°C: 4.55% to 4.89%. Longer drying time allows for more complete dehydration and reduction of volatile compounds, further concentrating the mineral content. The ash content was lower compared to 7.60% and 5.8% reported value obtained by Igwe *et al*. (2011) on edible winged African termite and *Hlongwane et al. (* 2020) on African termite respectively.

 The consistent increase in ash content with both time and temperature indicates that **drying intensifies the concentration of non-volatile mineral components.** The highest ash value (4.89%) at **100°C for 18 hr** confirms that **intense drying conditions maximize mineral retention** in the termite samples. Ash content represents total minerals content in foods and thus, serves as a viable tool for nutritional evaluation of minerals (Lienel, 2002).

**Table 1: Proximate composition (%) and energy value (kcal) of the oven dried edible winged African termites *(Macrotermes nigeriensis****)*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Drying temperature (°)** | **Drying time (h)** |  | **Moisture**  | **Crude protein** | **Crude fat**  | **Crude fibre**  | **Ash**  | **Carbohydrate**  | **Energy value** |
| **50** | 6 |  | 8.79a±0.04 | 34.67i±0.02 | 34.12i±0.03 | 1.63h±0.04 | 2.56i±0.02 | 18.25a±0.04 | 518.74g±0.51 |
|  | 12 |  | 8.07b±0.04 | 35.49h±0.01 | 34.52h±0.03 | 1.67gh±0.01 | 2.85h±0.03 | 17.40b±0.04 | 522.24f±0.14 |
|  | 18 |  | 7.89c±0.04 | 36.53g±0.20 | 35.03g±0.01 | 1.73ef±0.01 | 2.96g±0.04 | 15.87c±0.19 | 532.85c±0.16 |
| **75** | 6 |  | 7.16d±0.03 | 37.08f±0.03 | 35.20f±0.01 | 2.03c±0.03 | 3.44f±0.02 | 15.10d±0.04 | 525.50e±0.16 |
|  | 12 |  | 6.86e±0.03 | 37.96e±0.01 | 35.92e±0.01 | 2.09b±0.02 | 3.58e±0.01 | 13.60e±0.02 | 529.50d±0.01 |
|  | 18 |  | 6.69f±0.05 | 38.25d±0.02 | 36.62c±0.02 | 2.14a±0.03 | 3.78d±0.02 | 12.54f±0.06 | 532.68c±0.12 |
| **100** | 6 |  | 6.06g±0.05 | 39.83a±0.02 | 36.43d±0.02 | 1.72fg±0.02 | 4.55c±0.06 | 12.12g±0.13 | 532.85c±0.23 |
|  | 12 |  | 5.52h±0.04 | 39.49b±0.01 | 37.03b±0.02 | 1.78e±0.01 | 4.72b±0.01 | 11.47h±0.05 | 537.05b±0.05 |
|  | 18 |  | 4.65i±0.06 | 39.14c±0.03 | 37.73a±0.01 | 1.87d±0.02 | 4.89a±0.02 | 11.04i±0.06 | 543.05a±0.47 |

Values are mean ± standard deviation of duplicate determination. Means in the same column followed by different superscripts are significantly (p<0.05) different.

**3.6 Carbohydrate content**.

There was a significant (P<0.05) decrease in the carbohydrate of the edible winged African termites with effect of temperature at constant time at a fixed time of 6 hours, carbohydrate content drops from 18.25% at 50°C to 12.12% at 100°C.This suggests that higher temperatures accelerate the breakdown or loss of carbohydrates, possibly due to thermal degradation or reactions like caramelization and the Maillard reaction, which reduce sugar content.

At constant temperature 50oC, processed for 6 hr had 18.25%, 12 hr had 17.40% and 18 hr had 15.87%. At constant 75oC, samples processed for 6 hr had 15.10%, 12 hr had 13.60% and 18 hr had 12.54%. At constant 100oC, samples processed for 6 hr had 12.12%, 12 hr had 11.47% and 18 hr had 11.04%. Effect of time at constant temperature: At 50°C, carbohydrate content decreases from 18.25% (6 hr) to 15.87% (18 hr). At 75°C and 100°C, similar declines are observed. This indicates that longer heat exposure leads to a progressive reduction in carbohydrate levels, likely from continued breakdown or leaching of sugars. The edible African termite had higher carbohydrate content of 18.25% at 50oC for 6hr and 11.04% at 1000C for 18 hr which was lower compared to 20.74% and 23.2% reported by Igwe *et al.* (2011) on edible winged African termite and *Hlongwane et al.* (2020) on African termite. Both **increased temperature** and **longer processing time** lead to a **reduction in carbohydrate content,** primarily due to heat-induced chemical changes and potential loss of soluble sugars. Carbohydrates play a very important role in human nutrition as they are the primary source of energy. Carbohydrates found in different edible insects varied from 5–51% of the different insect (Kourinska and Adamkova 2019). Therefore, edible insects can be used as a source of carbohydrates, as they contain relatively high amounts of polysaccharides, which play an important role in enhancing the immune system of the human body Chen *et al*. (2009). In addition, carbohydrates are an essential nutritive element in the human body (*Hlongwane et al.,* 2020)

**3.2** **MINERAL COMPOSITION**

**3.2.1 Calcium content**

The calcium content of the edible winged African termites as observed on Table 2 below. There was a significant (P<0.05) increase in the samples dried at higher temperature for lower time**. Effect of drying temperature as the drying temperature increases (from 50°C to 100°C) the calcium content increases. A**t 50°C, calcium ranges from **222.92 to 224.64 mg/100g**. At 75°C, it increases to **225.85 to 226.98 mg/100g**. At 100°C, it reaches **228.08 to 229.82 mg/100g**.This suggests that **higher drying temperatures help preserve or enhance measurable calcium content** in the sample, possibly due to reduced moisture interference with measurements, less degradation of calcium at shorter drying times. **Effect of drying time at each temperature level, an increase in drying time tends to slightly reduce calcium content** for example, at 100°C 6 h increased to **229.82 mg/100g,** 12 hr increased to **228.71 mg/100g,** 18 hr increased to **228.08 mg/100g.** The same trend appears at 75°C and 50°C. The **highest calcium retention** is at **100°C for 6 hr (229.82 mg/100g).** The **lowest was at 50°C for 18 hr (222.92 mg/100g)**. This suggests that **shorter drying times and higher temperatures favor calcium retention** in the sample.Higher temperatures dry the sample faster, reducing leaching or degradation of calcium compounds. **Thermal stability of calcium**: calcium is relatively heat-stable, so higher temperatures don't degrade it, but long exposure (longer drying time) may still cause minimal losses due to other processes. As moisture is removed more efficiently at higher temperatures, the concentration of calcium per 100g of dried material appears higher. The calcium content of the samples was higher than that of Igwe *et al*. (2011) findings who reported calcium content as 9.56mg/kg on edible winged termite. This was in agreement with Dobermann *et al.* (2019) finding who reported that calcium content of black cricket showed a significant difference between the two processing temperature

Calcium is the most abundant mineral in the body. Humans need calcium to build and maintain strong bones, and [99%](https://ods.od.nih.gov/factsheets/Calcium-HealthProfessional/) of the body’s calcium is in the bones and teeth. It is also necessary for maintaining healthy communication between the brain and other parts of the body. It plays a role in muscle movement and cardiovascular function.

**3.2.2. Magnesium content.**

The edible winged African termite processed at constant temperature of 50oC and varied time of 6hr had Magnesium value of 27.44 mg/100g, 12 hr had 26.38 mg/100g and 18 hr had 25.68 mg/100g. Magnesium content decreases with increasing time. Possibly due to slow but progressive degradation or leaching of magnesium at this lower temperature over time. At constant 75oC, 6 hr had 30.28 mg/100g, 12 hr had 29.67 mg/100g and 18 hr had 28.74 mg/100g. The same decreasing trend, but overall **higher magnesium retention** than at 50°C. Moderate heat may enhance nutrient release (via cell breakdown) initially, but extended time still causes losses. At constant 100oC, 6 hr had 31.92 mg/100g, 12hr had 31.13 mg/100g and 18 hr had 30.97 mg/100g. Magnesium content was highest at this temperature and shows **minimal reduction over time** which suggests efficient nutrient release with relatively stable retention even after prolonged heating.

 At constant time of 6 hr with varied temperature of processing, at 50oC had magnesium value of 27.44 mg/100g, at 75oC: 30.28 mg/100g at 100oC: 31.92 mg/100g. Magnesium content increases with temperature. Short-term high heat may enhance breakdown of cellular matrices, releasing more magnesium. At constant 12 hr, at 50oC: 26.38 mg/100g, at 75oC: 29.67 mg/100g, at 100oC: 31.13 mg/100g. Higher temperature leads to greater magnesium yield. At constant 18 hr, at 50oC: 25.68 mg/100g, at 75oC: 28.74 mg/100g, at 100oC: 30.97 mg/100g. The same trend again, though with slightly less magnesium due to extended processing. The finding was lower than that reported by Igwe *et al*. (2011) on oven dried edible African termite with 60.96mg/kg.

There was a significant (P<0.05) increase on the edible winged African termite oven dried at higher temperature (100oC) and lower time (6h). Mg plays a crucial part in Ca metabolism in bones and regulates blood pressure and insulin releases (Ugwuarua, 2010). Magnesium is a cofactor in more than 300 enzyme systems that regulate diverse biochemical reactions in the body, including protein synthesis, muscle and nerve function, blood glucose control, and blood pressure regulation (Aydin *et al.*, 2010). It is required for energy production, oxidative, phosphorylation and glycolysis. It contributes to the structural development of bone and is required for the synthesis of DNA, RNA and the antioxidant glutathione, if consumed regularly.

**Table 2: Mineral composition of the oven dried edible winged African termites *(Macrotermes nigeriensis****)*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Drying temperature(°C)** | **Drying time (h)** | **Calcium (mg/100 g)**  | **Magnesium (mg/100 g)** | **Iron (mg/100 g)** |  **Copper (mg/100g)** |  | **Zinc (mg/100 g)** |
| **50** | 6 | 224.64f±0.03 | 27.44g±0.03 | 1.87g±0.01 | 1.61g±0.02 |  | 1.87g±0.02 |
|  | 12 | 224.03g±0.74 | 26.38h±0.03 | 1.61h±0.01 | 1.27h±0.04 |  | 1.32h±0.02 |
|  | 18 | 222.92h±0.02 | 25.68i±0.03 | 1.20i±0.01 | 0.92i±0.01 |  | 1.09i±0.03 |
| **75** | 6 | 226.98d±0.01 | 30.28d±0.01 | 2.50d±0.01 | 2.71d±0.02 |  | 2.98d±0.01 |
|  | 12 | 226.14e±0.03 | 29.67e±0.02 | 2.20e±0.03 | 2.25e±0.04 |  | 2.40e±0.02 |
|  | 18 | 225.85e±0.01 | 28.74f±0.00 | 2.03f±0.03 | 1.97f±0.03 |  | 2.10f±0.01 |
| **100** | 6 | 229.82a±0.03 | 31.92a±0.01 | 2.96a±0.01 | 3.62a±0.01 |  | 4.58a±0.03 |
|  | 12 | 228.71b±0.03 | 31.13b±0.04 | 2.90b±0.01 | 3.21b±0.03 |  | 4.18b±0.01 |
|  | 18 | 228.08c±0.03 | 30.97c±0.01 | 2.73c±0.01 | 3.04c±0.02 |  | 3.58c±0.04 |

Values are mean ± standard deviation of duplicate determination. Means in the same column followed by different superscripts are significantly (p<0.05) different.

 **3.2.3 Iron content**

There was a significance (P<0.05) increase observed. The edible winged African termite processed at constant temperature of 50oC with varied time of 6hr had Iron value of 1.87 mg/100g, 12 hr had 1.61 mg/100g and 18 hr had 1.20 mg/100g. Iron content steadily decreaseswith increasing time. This suggests potential **leaching, oxidation,** or **thermal degradation** of iron compounds at this low temperature over extended periods. At constant 75oC, 6 hr had 2.50 mg/100g, 12 hr had 2.20 mg/100g and 18 hr had 2.03 mg/100g. A similar decreasing trend with time was observed, but iron levels was **consistently higher** than at 50°C, indicating improved extractability or release of iron at elevated temperatures. At constant 100oC, 6 hr had 2.96 mg/100g, 12hr had 2.90 mg/100g and 18 hr had 2.73 mg/100g. Iron content remains **highest** at 100°C, and the decline over time is **minimal**, suggesting that iron is more stable and more effectively retained at this higher temperature.

At constant time of 6 hr with varied temperature of processing, 50oC had iron value of 1.87 mg/100g, 75oC: 2.50 mg/100g 100oC: 2.96 mg/100g. There is a clear and substantial increase in iron content as temperature rises. Processing at 100°C releases nearly **60% more iron** than at 50°C. This suggests that higher temperatures improve the bioavailability or extractability of iron from the insect tissue. At constant 12 hr, at 50oC: 1.61 mg/100g, at 75oC: 2.20 mg/100g, at 100oC: 2.90 mg/100g. Again, a consistent increase is observed with temperature. Iron levels at 100°C are **almost double** that at 50°C. The temperature effect is stronger than the time-related degradation, indicating that **high heat facilitates iron release**, even with moderate processing time At constant 18 hr, 50oC: 1.20 mg/100g, 75oC: 2.03 mg/100g, 100oC: 2.73 mg/100g. Although 18 hours is a long processing time and overall iron content is lower than at shorter durations, higher temperatures continue to preserve significantly more iron. **100°C maintains over 2 times the iron content** of 50°C even at prolonged exposure. This data supports **high-temperature, short-duration** processing for preserving iron a vital mineral in addressing **micronutrient deficiencies,** especially in populations at risk of **iron deficiency anemia**. It highlights the potential of **edible insects as iron-rich foods**, particularly when processed under **optimized thermal conditions.** These findings can guide **industrial processing, home preparation,** or **policy recommendations** for promoting edible insect consumption as a sustainable and nutritious food source.

The iron content of the edible winged African termite was observed to be of the range 1.20mg/100g to 2.96mg/100g which was higher compared to the findings of Fombong and Kinyuru (2019) on edible winged African termite who reported 0.96mg/100g but lower than that reported by Igwe *et al.* (2011) who recorded 9.56mg/kg as the Iron content of the oven dried edible winged African termite.

**3.2.4 Copper content**

Table 2, 3 showed that the copper content of the sample edible winged African termite dried at higher temperature and lower time had significant (P<0.05) increase. The edible winged African termite processed at constant temperature of 50oC with varied time of 6 hr had copper value of 1.61mg/100g, 12 hr had 1.27 mg/100g and 18 hr had 0.92 mg/100g. There was a **steady decline** in copper content with increased processing time. This may be attributed to: **Leaching** into processing fluids due to prolonged exposure at low temperature. **Slow oxidative degradation** of copper-containing compounds. In-complete release of bound copper due to insufficient thermal energy. At constant 75oC, 6 hr had 2.71 mg/100g, 12 hr had 2.25 mg/100g and 18 hr had 1.97 mg/100g. Copper content remains **consistently higher** than at 50°C. However, a time-dependent decline still exists, although **less steep**. This implies that: Moderate heat enhances **release and retention** of copper initially. Extended exposure still leads to some degradation or leaching. At constant 100oC, 6 hr had 3.62 mg/100g, 12hr had 3.21 mg/100g and 18 hr had 3.04 mg/100g. At this high temperature: **Maximum copper levels** were achieved. Decline over time was **minimal**, indicating greater stability and possibly more effective denaturation of proteins that bind copper, making it more bioavailable. This suggests **high-temperature, short-time** processing is optimal for copper retention.

At constant time of 6 hr with varied temperature of processing, 50oC had iron value of 1.61 mg/100g, at 75oC: 2.71 mg/100g at 100oC: 3.62 mg/100g. As temperature increases, copper content increases significantly. This supports the idea that **higher thermal energy enhances copper extraction or release** from internal tissues. At constant 12 hr, 50oC: 1.27 mg/100g, 75oC: 2.25mg/100g, 100oC: 3.21 mg/100g. Same pattern persists. There was almost a **threefold increase** in copper at 100°C compared to 50°C. Temperature plays a **critical role** in copper retention or enhancement. At constant 18 hr, 50oC: 0.92 mg/100g, at 75oC: 1.97 mg/100g, at 100oC: 3.04 mg/100g. Even after 18 hours, copper content remains much higher at elevated temperatures. This suggests that while time slightly reduces copper levels**, temperature has a dominant positive effect. Optimal condition for copper retention** was **100°C for 6 to 12 hours**, where the highest concentrations are consistently observed. The copper content of the sample was observed to be higher than that of Igwe *et al*. (2011) and Fombong and Kinyuru (2019) who obtained 0.72mg/kg and 0.07mg/100g respectively, as the copper content of the sample edible winged African termite.  copper is required for infant growth, host defense mechanisms, bone strength, red and white cell maturation, iron transport, cholesterol and glucose metabolism, myocardial contractility, and brain development (Araya *et al*., 2007)

**3.2.5 Zinc content (Zn)**

The zinc content of the sample edible winged African termite obtain ranged from 1.09 to 4.58mg/100g. There was a significant increase (P<0.05) in the zinc content obtained from the sample edible winged African termite oven dried at higher temperature and lower time as shown on the table 2. The edible winged African termite processed at constant temperature of 50oC with varied time of 6hr had zinc value of 1.87 mg/100g, 12 hr had 1.32 mg/100g and 18 hr had 1.09 mg/100g. There was a **progressive decline** in zinc content over time. This could be due to: **Leaching** of zinc into moisture retained in the sample, **slow thermal degradation** of zinc-binding proteins or organic structures, Zinc being lost due to oxidation or transformation into less detectable forms. At constant 75oC, 6 hr had 2.98 mg/100g, 12 hr had 2.40 mg/100g and 18 hr had 2.10 mg/100g. Zinc content was significantly **higher than at 50°C** across all time points. However, a similar time-dependent decrease was observed. This suggests: Moderate temperatures enhance zinc **release from insect tissue**, but prolonged exposure still leads to some **mineral loss**. At constant 100oC, 6 hr had 4.58 mg/100g, 12hr had 4.18 mg/100g and 18 hr had 3.58 mg/100g. Zinc content was **highest overall** at 100°C, and the decline over time was **less pronounced**. This indicates: **High thermal energy promotes efficient release** of bound zinc; Zinc was relatively **thermo stable**, especially during shorter durations, some loss still occurs over long exposure due to **oxidation** or **volatilization** of zinc-containing compounds.

At constant time of 6 hr with varied temperature of processing, 50oC had zinc value of 1.87 mg/100g, 75oC: 2.98 mg/100g 100oC: 4.58 mg/100g. There was a **strong temperature-dependent increase** in zinc concentration. Processing at 100°C results in nearly a **2.5-fold increase** compared to 50°C. This suggests that heat breaks down barriers (e.g., cell walls, protein matrices) that limit zinc availability. At constant 12 hr, 50oC: 1.32 mg/100g, 75oC: 2.40 mg/100g, 100oC: 4.18 mg/100g. Zinc contained more than **triples** when the temperature increases from 50°C to 100°C. This underscores the **dominant role of temperature** in enhancing mineral release, even over longer durations. At constant 18 hr, 50oC: 1.9 mg/100g, at 75oC: 2.10 mg/100g, 100oC: 3.58 mg/100g. Despite the long exposure time, zinc content at 100°C remains **over 3 times higher** than at 50°C. The data highlights that **temperature was more influential than time** in determining zinc content in processed termites.

The Zinc content obtained was higher than that obtained by Fombong and Kinyuru (2019) who obtained 0.1mg/100g for the Zinc content.

Zinc is an essential mineral for the proper function of the human body (Zoroddu et al., 2019). For example, zinc can improve chondrocyte and osteoblast function while reducing osteoclast activity, indicating a role for the metal in bone homeostasis and regeneration. It is involved in numerous physiological processes (O'Connor *et al*., 2020). Zinc is a crucial trace element involved in **immune function, wound healing, and cellular metabolism**. Enhancing its availability in edible insects supports their role in **nutritional security**. The findings advocate for **high-temperature processing methods** (e.g., boiling, roasting, oven-drying at 100°C) to optimize the **micronutrient profile** of insect-based foods. These results can inform **food industry practices, traditional preparation methods**, and **policy** promoting insects as **nutrient-rich, sustainable protein source**.

**4.3 AMINO ACID COMPOSITION OF THE OVEN DRIED EDIBLE WINGED AFRICAN TERMITES (*Macrotermes nigeriensis****)*

The edible winged African termite is a rich source of essential and non-essential amino acid. Table 3 showed the eighteen (18) amino acids detected comprising both Nine (9) essential amino acids (EAA) which are Leucine, Lysine, Phenylalanine, Isoleucine, Histidine, Valine, Threonine, Methionine and Trytophan. The nine (9) non-essential amino acids (NEAA) are Glutamic acid, Aspartic acid, Arginine, Alanine, Serine, Proline, Glycine, Tyrosine and Cysteine.

The essential amino acid (EAA) Leucine had the highest value (7.47mg/100g) at constant time of 6hr and varied temperature, samples processed at 50oC had leucine value of 6.12mg/100g, at 75oC was 7.47 mg/100g and at 100oC was 7.53 mg/100g. At constant time of 12hr and varied temperature, samples processed at 50oC had leucine value of 6.26 mg/100g, at 75oC had 5.76 mg/100g and at 100oC had 5.81 mg/100g. At constant time of 18 hr and varied temperature, samples processed at 50oC had leucine value of 5.24 mg/100g, at 75oC had 5.65 mg/100g and at 100oC had 5.64 mg/100g. This showed a significant (p<0.05) increase which implied that at 6hr of processing maximal leucine could be obtained at 100oC and that was as a result of shorter time high temperature.

At constant temperature of 50oC and varied time, leucine value at 6 hr was 6.12mg/100g, at 12 hr was 6.26mg/100g and at 18 hr was 5.24mg/100g. At constant 75oC and varied time, leucine value at 6 hr was 7.47mg/100g, at 12 hr was 5.76mg/100g and at 18 hr was 5.65mg/100g. At constant 100oC and varied time, leucine value at 6 hr was 7.53mg/100g, at 12 hr was 5.81mg/100g and at 18 hr was 5.64mg/100g. This values significantly (p<0.05) decreased. Therefore maximum value was obtained at 50oC

 followed by Lysine (6.91mg/100g), Phenylalanine (4.57mg/100g) Isoleucine (4.94mg/100g), Histidine (3.36mg/100g), Valine (3.35mg/100g), Threonine (3.25mg/100g), Methionine (2.35mg/100g) and Tryptophan (1.17mg/ 100g) with the lowest amino acid and the non-essential amino acids (NEAA) Glutamic acid (13.44mg/100g) had the highest value followed by Aspartic acid (8.62mg/100g), Arginine (6.19mg/100g), Alanine (4.52mg/100g), Serine (4.49mg/100g), Proline (4.47mg/100g), Glycine (3.76mg/100g), Tyrosine (3.28mg/100g) and Cysteine (0.82mg/100g) which had the lowest amino acid.

There was significant (P<0.05) increase observed among the temperatures and time used for drying of the edible winged African termite. As observed from the Table 3, the total amino acid at temperature 100oC for 6 hr was the highest with total amino acid of 85.46mg/100g. Leucine, Lysine, Isoleucine, Phenylalanine, Trytophan, Valine, Methionine, Proline and others obtained at temperature 75oC, and 100oC for 6 hr had higher values than others while at temperature 75oC and 100oC for 18 hr showed the least effect on the amino acid.

The amino acid Leucine (7.47mg/100g), Lysine (6.91mg/100g), Isoleucine (4.94mg/100g), Phenylalanine (4.57mg/100g), Trytophan (1.17mg/100g), Valine (3.35mg/100g), Methionine (2.35), Proline (4.47mg/100g protein) values obtained from the study were lower compared to the findings of Fombong and Kinyuru (2018) who stated that the termite proteins were considerably lower in all the essential amino acids with the result: methionine (7.93mg/100g), cysteine (6.53mg/100g), lysine (40.58mg/100g) and threonine (23.23 mg/g protein) which were higher. Some of the essential and non essential amino acids of this research were higher to that of Elemo *et al*. (2011) who compared the amino acid of palm weevil and egg. The finding on amino acids content of edible winged African termite was significantly affected by drying temperature 100oC and 75oC and a prolong timing of 18 hr which was in agreement with previous finding by Bellagamba *et al.* (2015) who reported a significant effect on the in vitro protein digestibility of processed animal proteins (PAPs)from the prolonged temperature treatment and also by Kinyuru *et al.*(2010)who reported on the influence of processing methods of toasting and solar drying on the in vitro protein digestibility of edible winged termites.

Amino acids are building blocks of protein and vital biological components required in the human body for biosynthesis, neurotransmission and other metabolic activities (Adebiyi *et al*., 2017). Their functions in the body include wound healing, tissue repairs, giving cells their structure, transporting and storing nutrients, as well as involvement in the formation of muscles, arteries and glands.

**Table 3: Amino acid profile (mg/ 100g protein) of the oven dried edible winged African termites *(Macrotermes nigeriensis****)*

|  |  |  |  |
| --- | --- | --- | --- |
| **Amino acid** |  **50 °C** |  **75 °C** |  **100 °C** |
| 6 h | 12 h | 18 h | 6 h | 12 h | 18 h | 6 h | 12 h | 18 h |
| **EAA****Leucine** | 6.12c±0.04 | 6.26b±0.07 | 5.24f±0.11 | 7.47a±0.03 | 5.76de±0.05 | 5.65e±0.05 | 7.53a±0.02 | 5.81d±0.05 | 5.64e±0.03 |
| **Lysine** | 5.69d±0.07 | 5.82cd±0.03 | 4.91f±0.10 | 6.91a±0.08 | 5.78cd±0.02 | 5.90c±0.07 | 6.97a±0.06 | 6.19b±0.01 | 5.50e±0.02 |
| **Isoleucine** | 4.13c±0.03 | 4.09c±0.04 | 3.94d±0.07 | 4.94a±0.06 | 4.25b±0.06 | 4.14c±0.01 | 4.94a±0.03 | 3.83e±0.04 | 3.89de±0.04 |
| **Phenylalanine** | 3.90e±0.012 | 4.08d±0.01 | 4.03d±0.06 | 4.57a±0.05 | 3.73f±0.01 | 3.59g±0.06 | 4.43b±0.01 | 4.21c±0.06 | 3.42h±0.06 |
| **Trytophan** | 1.08b±0.04 | 1.06bc±0.04 | 0.99cd±0.02 | 1.17a±0.02 | 0.92de±0.07 | 1.00bcd±0.04 | 1.22a±0.01 | 1.05bc±0.00 | 0.87e±0.00 |
| **Valine** | 3.04c±0.04 | 3.13bc±0.04 | 2.83d±0.17 | 3.35a±0.01 | 3.01c±0.01 | 3.02c±0.03 | 3.22ab±0.05 | 3.33a±0.04 | 3.34a±0.04 |
| **Methionine** | 2.26ab±0.02 | 2.25ab±0.01 | 2.14c±0.12 | 2.35a±0.04 | 2.23bc±0.01 | 2.29ab±0.02 | 2.29ab±0.02 | 2.23bc±0.01 | 2.31ab±0.01 |
| **Proline** | 4.26b±0.01 | 4.11c±0.07 | 3.50e±0.07 | 4.37ab±0.01 | 4.01c±0.06 | 4.06c±0.01 | 4.47a±0.01 | 3.76d±0.01 | 3.71d±0.09 |
| **Histidine** | 3.10b±0.05 | 3.13b±0.04 | 2.64d±0.02 | 3.36a±0.04 | 2.84c±0.06 | 2.86c±0.01 | 3.27a±0.03 | 2.88c±0.13 | 2.46e±0.04 |
| **NEAA** |  |  |  |  |  |  |  |  |  |
| **Arginine** | 5.79c±0.06 | 5.77c±0.01 | 5.46e±0.06 | 5.98b±0.04 | 6.06ab±0.07 | 6.11ab±0.13 | 6.19a±0.01 | 6.06ab±0.06 | 5.60d±0.01 |
| **Tyrosine** | 3.09bc±0.00 | 3.01c±0.11 | 2.75d±0.00 | 3.10bc±0.01 | 2.75d±0.00 | 2.76d±0.01 | 3.18ab±0.11 | 3.01c±0.11 | 3.28a±0.01 |
| **Cysteine** | 0.79ab±0.00 | 0.82a±0.04 | 0.63d±0.04 | 0.79ab±0.00 | 0.70c±0.04 | 0.73bc±0.01 | 0.76abc±0.05 | 0.73bc±0.00 | 0.55e±0.01 |
| **Alanine** | 4.52a±0.03 | 4.52a±0.05 | 4.05d±0.06 | 4.44ab±0.06 | 4.36b±0.06 | 4.31b±0.09 | 4.34b±0.01 | 4.42ab±0.04 | 4.18c±0.04 |
| **Glutamic acid** | 12.92c±0.10 | 13.17b±0.12 | 11.01g±0.07 | 13.44a±0.02 | 12.48de±0.08 | 12.68d±0.09 | 13.24ab±0.08 | 12.26e±0.09 | 11.33f±0.19 |
| **Glycine** | 3.36cd±0.05 | 3.54b±0.04 | 2.92e±0.04 | 3.76a±0.02 | 3.42c±0.02 | 3.27d±0.09 | 3.66a±0.08 | 3.54b±0.04 | 3.27d±0.01 |
| **Threonine** | 3.18ab±0.02 | 3.07bc±0.05 | 2.83d±0.12 | 3.25a±0.07 | 3.22a±0.05 | 3.07bc±0.02 | 3.26a±0.01 | 3.15ab±0.06 | 3.01c±0.03 |
| **Serine** | 3.72bcd±0.04 | 3.62cde±0.04 | 3.33ef±0.06 | 4.49a±0.02 | 3.26f±0.36 | 3.58cde±0.11 | 3.96b±0.06 | 3.85bc±0.05 | 3.41def±0.05 |
| **Aspartic acid****Total amino acid** | 7.20c±0.0270.95 | 7.15c±0.0671.95  | 6.83d±0.0763.2  | 8.62a±0.0276.14  | 7.07c±0.1168.78  | 6.81de±0.0169.02  | 8.53a±0.0685.46  | 7.62b±0.0677.93 | 6.68e±0.0672.45 |

Values are mean ± standard deviation of duplicate determination. Means in the same row followed by different superscripts are significantly (p<0.05) different.

EAA means Essential Amino Acids while NEAA means Non Essential Amino Acids.

The amino acid Leucine (7.47mg/100g), Lysine (6.91mg/100g), Isoleucine (4.94mg/100g), Phenylalanine (4.57mg/100g), Trytophan (1.17mg/100g), Valine (3.35mg/100g), Methionine (2.35), Proline (4.47mg/100g protein) values obtained from the study were lower compared to the findings of Fombong and Kinyuru (2018) who stated that the termite proteins were considerably lower in all the essential amino acids with the result: methionine (7.93mg/100g), cysteine (6.53mg/100g), lysine (40.58mg/100g) and threonine (23.23 mg/g protein) which were higher. Some of the essential and non essential amino acids of this research were higher to that of Elemo *et al*. (2011) who compared the amino acid of palm weevil and egg. The finding on amino acids content of edible winged African termite was significantly affected by drying temperature 100oC and 75oC and a prolong timing of 18h which was in agreement with previous finding by Bellagamba *et al.* (2015) who reported a significant effect on the in vitro protein digestibility of processed animal proteins (PAPs)from the prolonged temperature treatment and also by Kinyuru *et al.*(2010)who reported on the influence of processing methods of toasting and solar drying on the in vitro protein digestibility of edible winged termites.

Amino acids are building blocks of protein and vital biological components required in the human body for biosynthesis, neurotransmission and other metabolic activities (Adebiyi *et al*., 2017). Their functions in the body include wound healing, tissue repairs, giving cells their structure, transporting and storing nutrients, as well as involvement in the formation of muscles, arteries and glands.

**4.4 FATTY ACID COMPOSITION OF THE OIL EXTRACTED FROM THE OVEN DRIED EDIBLE WINGED AFRICAN TERMITES *Macrotermes nigeriensis****)*

Table 4 below shows the results obtained for fatty acid composition of the oil extracted from the edible winged Africa termite oven dried at different temperature and time. Differences were noted in the values obtained within the same processing temperature and time as well as between processing temperature and time.

Palmitoleic acid (an omega-7 monounsaturated fatty acid) was observed to be the most abundant fatty acid with the range of 0.24 - 53.24%. At constant temperature of 50oC and varied time, palmitoleic acid value for 6 hr was 53.24%, 12 hr was 32.8% and 18 hr was 9.8%. Samples processed at constant temperature of 75oC and varied time, palmitoleic acid value for 6 hr was 25.1%, 12 hr was 27.81% and 18hr was 16.37%. At constant 100oC and varied time, palmitoleic acid was 38.11%, 12 hr was 2.39% and 18 hr was 0.24%. This showed a significant (p<0.05) decrease which implied that at 50oC of processing a maximum palmitoleic acid could be obtained for 6hr.

At constant time of 6 hr and varied temperature, samples processed at 50oC had palmitoleic acid value of 53.24%, at 75oC was 25.1% and at 100oC was 3.39%. At constant 12 hr palmitoleic acid value at 50oC was 32.8%, at 75oC was 27.81% and at 100oC was 3.39%. At constant 18 hr and varied temperature, sample processed at 50oC was 9.8%, at 75oC was 16.37% and at 100oC was 0.24%. The values significantly (p<0.05) reduced. Therefore, maximum value of palmitoleic acid was at 6 hr of processing at 50oC. The finding was observed to be higher than that of Ekpo and Onigbinde, (2007) on winged reproductive of the termite whose finding was 2.10% and that of Fombong and Kinyuru (2018) on edible winged termite with 0.62% for the palmitoleic acid.

Palmitic acid (C16:0) (a saturated long-chain fatty acid) was observed to be of the range 0.25 – 14.32%. At constant temperature of 50oC and varied time, palmitic acid value at 12 hr was 3.09% and at 18 hr was 0.55%. Samples processed at constant temperature of 75oC and varied time, palmitic acid value for 6 hr was 1.25%, 12hr was 0.27% and 18 hr was 14.32%. At constant 100oC and varied time, palmitic acid for 6 hr was 0.25%. This showed a significant (p<0.05) decrease. At constant time of 6 hr and varied temperature, sample processed at 75oC was 1.25% and at 100oC was 0.25%. At constant 12 hr palmitic acid value at 50oC was 3.09%, at 75oC was 0.27%. At constant 18 hr and varied temperature, sample processed at 50oC was 0.55%, at 75oC was 14.32%. The values significantly (p<0.05) reduced. Samples processed at 75oC for 18 hr had the highest palmitic value (14.32%) whereas drying for 12 hr yields the least palmitic value (0.27%).

**Table 4: Fatty acid composition (Percentage abundance %) of the oil extracted from the oven dried edible winged African termites *(Macrotermes nigeriensis****)*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Fatty acids** | **6h** | **500C****12h** | **18h** | **6h** | **750C****12h** | **18h** | **6h** | **1000C****12h** | **18h** |
| **Palmitoleic acid (C16:1)** | 53.24 | 32.8 | 9.8 | 25.1 | 27.81 | 16.37 | 38.11 | 3.39 | 0.24 |
| **palmitic acid (C16:0)** | - | 3.09 | 0.55 | 1.25 | 0.27 | 14.32 | 0.25 | - | - |
| **Oleic acid(C18:1)** | 16 | 26.02 | 49.7 | 27.3 | 1.48 | 13.2 | 33.2 | 2.48 | 19.3 |
| **vaccenic acid(C18:1)** | - | 17.02 | 10.8 | 15.8 | 12.2 | 10.21 | 2.86 | 44.12 | 14.1 |
| **6-octadecenoic acid(C18:1)** | 24.47 | 1.64 | 6.8 | 4.27 | 10.2 | 12.31 | 17.25 | - | - |
| **13-octadecenoic acid(C18:1)** | - | 4.32 | 3.2 | 12.02 | 26.02 | 6.94 | 0.31 | 3.39 | 6.5 |
| **10-nonadecenoicacid** | - | - | - | 0.5 | - | - | 3.54 | - | - |
| **erucic acid (C13:1)** | 6.29 | 7.03 | 10.2 | 3.95 | - | - | 4.48 | 4.36 | 32.86 |
| **Tetradecenoic acid** | - | - | 0.55 | 3.44 | - | 8.52 | - | 4.72 | - |
| **n-Hexadecanoic acid**  | - | - | 2.68 | 1.93 | 5.25 | - | - | 11.1 | - |
| **Octadecenoic acid** | - | - | 0.55 |  | 0.27 | 12.92 | - | 2.27 | - |
| **Octadec-9-enoic acid** | - | 3.14 | 2.2 | 4.44 | - | - | - | - | 27.0 |
| **Hexanoic acid** | - | 0.24 | - | - | - | - | - | - | - |
| **Tricosanoic acid** | - | 1.94 | - | - | - | - | - | - | - |
| **9-eicosenoic acid** | - | 2.76 | 2.97 | - | 15.02 | 5.21 | - | - | - |

Values are mean ± standard deviation of duplicate determination. Means in the same column followed by different superscripts are significantly (p<0.05) different.

It was observed that the finding falls in line with Dobermann *et al.* (2019) findings on black cricket and that of Alen *et al*. (2017) on freeze dried termite queen with 13.13% but lower to the findings of Elemo *et al. (*2011) on African palm weevil with 35.3% Palmitic acid.

Oleic acid (C18:1) (a monounsaturated omega-9 essential fatty acid) was the next in abundance with range 1.48 - 49.7%. At constant temperature of 50oC and varied time, oleic acid value for 6 hr time was 16%, 12 hr was 26.02% and 18hr was 49.7%. Samples processed at constant temperature of 75oC and varied time, oleic acid value for 6 hr was 27.3%, 12 hr was 1.48% and 18 hr was 13.2%. At constant 100oC and varied time, oleic acid for 6 hr was 33.2%, 12 hr was 2.48% and 18 hr was 19.3%. This showed a significant (p<0.05) difference which implied that at 50oC of processing a maximum oleic acid could be obtained at 18hr.

At constant time of 6hr and varied temperature, samples processed at 50oC had oleic acid value of 16%, at 75oC was 27.03% and at 100oC was 33.3%. At constant 12 hr oleic acid value at 50oC was 26.02%, at 75oC was 1.48% and at 100oC was 2.48%. At constant 18 hr and varied temperature, sample processed at 50oC was 49.7%, at 75oC was 13.2% and at 100oC was 19.3%. The values significantly (p<0.05) differs. Samples processing at 50oC for 18 h had the highest value (49.7%) It was observed that oleic acid obtained was lower to that reported by Igwe *et al.* (2011) with 52.45% oleic acid.

Vaccenic acid (a naturally occurring trans-fatty acid and an omega-7 fatty acid) was observed in percentage abundance to be of the range 2.86 - 44.12%. At constant temperature of 50oC and varied time, vaccenic acid value for 12hr was 17.02% and 18 hr was 10.8%. Samples processed at constant temperature of 75oC and varied time, vaccenic acid value for 6 hr was 15.8%, at 12 hr was 12.2% and at 18 hr was 10.21%. At constant 100oC and varied time, vaccenic acid at 6 hr was 2.86%, at 12 hr was 44.12% and 18hr was 14.1%. This showed a significant (p<0.05) effect which implied that at 100oC of processing a maximum vaccenic acid could be obtained at 12 hr

6-octadecenoic acid(C18:1) Strearic acid, Myristoleic acid, Erucic acid and others as shown on Table 4 were the fatty acids identified in the oil extracted from the oven dried edible winged African termite and was in agreement to Fombong and Kinyuru (2018) and Igwe *et al.* (2011) findings on African termite.

**CONCLUSION AND RECOMMENDATION**

In this study, the impact of processing temperature and time variability on the nutrient and oil profile of edible winged African termites was investigated. The results indicated that processing temperature and time had a significant impact on the nutrient content of the edible winged African termites. Higher temperatures and longer processing times led to a decrease in protein content but an increase in fat content whereas processing at high temperature of 75oC and 100oC for short time duration of 6h yield best result. This suggests that processing parameters can be optimized to achieve desired nutrient profiles in processed edible winged African termites. The oil profile of the edible African termites was also affected by processing temperature (100oC) and time (18h). Higher temperatures and longer processing times led to changes in the composition of fatty acids profile and physiochemical properties of the oil. These changes could have implications for the shelf life stability and nutritional quality of oil derived from edible winged African termites.

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