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PRODUCTION AND QUALITY EVALUATION OF WHEAT COOKIES ENRICHED WITH EDIBLE AFRICAN TERMITES *(Macrotermes nigeriensis)*

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ABSTRACT

Edible African termite (*Macrotermes nigeriensis)* was used in paste form for the production of wheat cookies. The wheat cookies enriched with *M. nigeriensis* were evaluated for proximate composition, anti-nutrients and mineral analysis as well as organoleptic attributes. The wheat-termite cookies showed no significant difference in the moisture and ash content values while significant difference existed in the samples in their protein, fat and carbohydrate compositions. The protein and fat contents were in the range of 9.05 – 15.69% and 9.14 – 12.7% respectively. The result of the nutrient analysis showed that most of the values increased as the level of inclusion of the edible termite increased. However it was not the same for the organoleptic properties of the wheat cookies enriched with edible African termite, *Macrotermes nigeriensis.* As the level of addition of *Macrotermes nigeriensis* paste increased, the rate of acceptability of the wheat cookies reduced, making samples AZ (100% wheat flour) and AQ (5% edible African termite; 95% wheat flour) to be the most acceptable by the members of the panel. The result of the antinutrients determined had low values and are within the acceptable level for consumption.

Keywords: African Termite, Wheat, Cookies,

INTRODUCTION

It is well known that hunger and malnutrition is a problem in human populations in many parts of the world. Apart from the incidence of hunger posed by the worsening food situation, the widespread prevalence of Protein Energy Malnutrition (PEM) has resulted in high morbidity and mortality rate especially among infants and children in developing countries including Nigeria. Rising incomes and rapid urbanization in developing countries are creating shifts in the composition of global food demand (Msangi and Rosegrant, 2011). With a growing world population and increasingly demanding consumers, the production of sufficient protein from livestock, poultry, and fish represents a serious challenge for the future. Approximately 1,900 insect species are eaten worldwide, mainly in developing countries and they constitute quality food and feed, have high feed conversion ratios, and emit low levels of greenhouse gases (Alamu *et al.,* 2013; Huis, 2013). The frequency of insect consumption around the world is poorly documented. The few examples found in literature are from Africa, Asia and Latin America. Insects can be found in abundance throughout the African continent and when staples are scarce they become important sources of food. Insects form part of the human diet in many tropical countries (Defoliart, 2012). Human consumption of insects (entomophagy) is often not promoted by national governments, and the focus is on Westernized dietary patterns as the standard to be emulated (Yen, 2009). The Western countries often consider entomophagy as a peculiar habit practiced only by "primitive man" in the tropics.

After being wild-harvested or reared in a domesticated setting, insects are killed by freeze-drying, sun-drying or boiling. They can be processed and consumed in three ways: as whole insects; in ground or paste form; and as an extract of protein, fat or chitin for fortifying food and feed products. Insects are also fried live and consumed. Ayieko *et al.*, (2010) reported that processing edible insects into conventional consumer products seems to encourage entomophagy. This has been in practice in Kenya, where termites and lake flies *(Chaoboridae and Chironomidae)* have been baked, boiled, steamed, and processed into crackers, muffins, sausages, and meat loaf (Ayieko *et al.*, 2010). Sorghum and Bambara nuts mixed with caterpillars has been reported as a protein-enriched food suitable for children 10 years of age and older (Allotey and Mpuchane, 2003). Processing influences the nutritional content of insects. Degutting the mopane caterpillar increased crude protein content and digestibility, whereas cooking lowered them, and hot coal–roasting elevated mineral content, probably due to contamination (Madibela *et al.,* 2007). Edible African termite (*Macrotermes nigeriensis)* as a local traditional food source have been neglected in the past, efforts should be made to ensure it receives more attention in the future in particular on how to manage this sustainable food source in the interest of food security. This research will help to make edible African termite palatable and nutritious for those that cannot eat them alone and how they can be made readily available through product development and differentiation.

MATERIALS AND METHODS

Source of Material

Macrotemes nigeriensis, winged termites known as 'aku' were collected from the field during early rainy season. Wheat flour and all other baking ingredients were obtained from Ekeukwu market Owerri Imo State. Reagents used for the chemical analysis were of analytical grade.

Processing of edible insects

Samples of adult *Macrotermes nigereinsis* collected from the field were washed dewinged, oven-dried at 40^{0}C to a constant weight and then milled into paste prior to use.

Preparation of Cookies Enriched with *Macrotemes nigeriensis*

The cookies were prepared using the cream –in method (Asomugha and Uwalaka, 2000). One hundred percent wheat flour served as the standard. The wheat cookies produced were enriched with *M.nigeriensis* milled paste at different substitution level (5 – 20%) with wheat flour.

Nutrient Analysis

The cookie samples were analyzed for moisture, ash, protein and fat contents according to the method of AOAC (2000). The parameters were determined in triplicates.

Evaluation of Anti-Nutritional Factors

Determination of Oxalate

The permanganate titration method described by *(Onwuka, 2005).* A measured weight of the sample was suspended in 100mls of distilled water and 5mls of 6mHCl was added. The mixture was digested by heating at 100^{0}C for an hour. It was cooled and filtered. Then the pH was adjusted by adding 2 drops of methyl red indicator followed by drop wise addition of concentrated aqueous ammonia solution (NH_40H) until a faint yellow colouration was obtained, at pH between 4-4.5. The mixture was heated to 90^{0}C in a water bath, cooled and filtered (to remove ferrous ion precipitates). The filtrate was again heated 90^{0}C and 10mls of 5% $CaCl_2$ solution was added with constant steering. It was allowed to cool and then allowed to stay overnight in the refrigerator (5^{0}C) the mixture was centrifuged at 3000xg for 6 minutes. The supernatant was decanted and the precipitate was dissolved in 10mls of 20% H_2S0_4. The solution was made up to 100mls with distilled water and was titrated against 0.05 KM_n04 solutions to a faint pink colour which persisted for 30 seconds. The oxalate content was given by the relationship that 1ml of 0.05m

KM_n^o4 solution = 0.00225g oxalate

Calculation of oxalate content

$$\% \text{ oxalate} = \frac{100 \times \text{titre} \times 0.00225}{W}$$

Where W = weight of sample used

Determination of Phytate

The oberlease Spectrophotometer method described by (*Onwuka, 2005)* was used. A weighed processed sample (2g) was extracted by mixing it with 50mls of 0.2N HCl solution and shaken for 30mins. It was filtered through whatman No. 42 filter paper to obtain the extract. Meanwhile standard phytate solution (sodium phytate), was prepared and diluted to a chosen concentration. An aliquot, 0.5mls of the extract as well as 1ml of the standard phytate solution was put in separate test tubes and treated with 1ml ferric solution (ferric ammonium sulphate). The tubes were corked with stoppers and boiled in a water bath for 30mins. They were cooled in ice for 15mins and then allowed to attain room temperature, then 2.0mls of 2,2 –Bipyrimidine solution was added to each tube, mixed well and their respective absorbance was read in a spectrophotometer at 519 nanometer wavelength. Calculation of phytate content of a sample

$$\% \text{ phytate} = \frac{100}{w} \times \frac{au}{as} \times \frac{C}{1000} \times \frac{vt}{va}$$

Where W = weight of sample

Au = absorbance of sample

As = absorbance of std phytate solution

C = concentration of std phytate (mg/ml)

Vt = total extract volume

Va = volume of extract used

Determination of Tannin

Tannin content of the sample was determined by Folin Denis Colometric method *(Krik and Sawyer, 1998).* A measured weight of the processed sample (5.0g) was mixed with distilled water in the ratio of 1:10 (w/v). The mixture was shaken for 30 minutes at room temperature filters obtain the extract. A standard tannic acid solution was prepared, 2ml of the standard solution and equal volume of distilled water was dispersed into a separate 50ml volumetric flask to serve as standard and reagent blank respectively. Then 2mls of each of the sample extract were put in their respective labelled flask. The content of each flask was mixed with 35ml distilled water and 1ml of the Folin Denis reagent was added to each. This was followed by 2.5mls of saturated Na_2C0_3 solution. There after each flask was diluted to the 50ml mark with distilled water and incubated for 90 minutes at room temperature. Their absorbance was measured at 760 min in a Spectrophotometer with the reagent blank at zero. Calculation of tannin content

$$\% \text{ tannin} = \frac{100 \times au \times C \times Vt}{w \times as \times Va}$$

W = weight of sample
Au = absorbance of test sample
As = absorbance of test sample
C = concentration of standard tannin solution
Vt = total volume of extract
Va = volume of extract analyzed

Determination of Saponin

This was done by the double solvent extraction gravimetric method *(Harborne, 1973).* 5.0g of the processed sample was mixed with 50mls of 20% aqueous ethanol solution and incubated for 12h at temperature of 55°C with constant agitation. After that, the mixture was filtered through Whitman No 42 grades of filter paper. The residue was re-extracted with 50ml of the ethanol solution for 30 minutes and the extracts were weighed together. The combine extract was reduced to about 40 mls by evaporation and then was transferred to a separating funnel and equal volume (40mls) of diety) ether was added to it. After mixing, there were partitioned and the other layer was discarded while the aqueous layer was reserved. This aqueous layer was re-extracted with the ether after which its pH was reduced to 4.5 with drop wise addition of dilute NaOH solution Saponin in the extract was taken up in successive extraction with 60ml and 30ml portion of named butanol. The combine entrant (ppt) was washed with 5% NaCl solution and evaporated to dryness in a previously weighed evaporation dish. The Saponin was dried in the oven at 60^0C (to remove any residual solvent) cooled in a dessicator and re-weighed. Calculation of Saponin content

$$\% \text{ Saponin} = \frac{W_2 - W_1}{W}$$

W = weight of sample used
W_1 = weight of empty evaporation dish
W_2 = weight of dish + Saponin extract.

Mineral Content Analysis

The mineral components were analyzed using an Atomic Absorption Spectrophotometer (AAS, Model SP9, Pychicham UK).

Sensory Analysis

The sensory attributes colour, taste, texture, flavour, aroma, appearance and general acceptability were evaluated by twenty member semi-trained panelist using a 9- point hedonic scale in which one represents dislike extremely while nine denotes like extremely (Iwe, 2007).

Statistical Analysis

All data generated from the experiment were analysed in triplicates and means subjected to analysis of variance (Iwe 2002).

RESULTS AND DISCUSSION

Proximate Composition of Cookie Samples Enriched with Milled Paste of *M. nigeriensis.*

The result of the proximate analysis is presented in Table 1.

Moisture Content

There were no significant differences in the moisture content of all the cookie samples. The moisture content values were in the range of 1.85 - 2.03%. These low values recorded in the moisture content may not have adverse effect on the quality attributes of the product (Kure *et al.,* 1998). Moisture content is an index of water activity (Olutiola *et al.*, 1991) and is used as a measure of stability and susceptibility to microbial contamination (Uraih and Izuagbe, 1990). The low moisture content values will also help to increase the shelf life of the cookies.

Protein Content

The protein content of the cookie samples as seen in Table 1 increased as the quantity of edible termite added increased. Though there was significant difference in the protein content of the samples; they were in the range 9.05 – 15.69%. This is in agreement with Asumugha and Uwalaka (2000) who reported that the protein content of cookies prepared from cocoyam/wheat flour ranged from 5.95-12.25%. The increased protein content with increasing levels of edible termite paste were expected because edible termites has been reported to have relatively high protein content (Igwe *et al.*, 2011). Protein is the basis of all organism activity and constitutes many important materials such as enzymes, hormones and haemoglobin. Edible insects have been shown to have higher protein content, on a mass basis, than other animal and plant foods such as beef, chicken, fish, soybeans, and maize (Teffo *et al.*, 2007). In Nigeria four popular edible insect species (*Imbrasia belina, Rhynchophorus phoenicis, Oryctes rhinoceros, Macrotermes bellicosus*) have been shown to contain all essential amino acids, with relatively high amounts of lysine, threonine, and methionine, which are the major limiting amino acids in cereal- and legume-based diets (Ekpo, 2011).

Ash Content

There were no significant differences in the ash content of the cookies. The ash content of the cookie samples ranged from 4.71 – 6.38%. The ash content of the cookies increased with increase in the edible termite paste proportion. Ash is a non-organic compound containing mineral content of food and nutritionally aid in the metabolism of other organic compounds such as fat and carbohydrate (William, 1978).

Fat Content

The fat content of the cookies ranged from 9.14 – 12.7%. Fat plays a role in determining the shelf life of foods. A high amount of fat can accelerate spoilage by promoting rancidity leading to the production of off flavours and odours. Also diets high in fat predispose consumers to different illnesses such as obesity, coronary heart disease etc. Therefore, the relatively low fat content observed in the cookies is desirable to both the processor and health conscious individuals (Okpala and Chinyelu, 2011). The fat content of food insects is variable among species, but the highest values are found in termites and palm weevil larvae (Bukkens, 1997). The termi*te, M. nigeriensis* has also been reported to be rich in oleic acid, palmitic acid and linoleic acid, an essential fatty acid, but poor in myristic acid, lauric acid and palmitoleic acid (Igwe *et al.*, 2011).

Carbohydrate Content

Sample AT (20% wheat flour; 80% edible termite paste) was significantly higher ($p<0.05$) with 75.09 % in the carbohydrate content while the least value was recorded in sample AZ (100% wheat flour) with 63.37% which implies that the cookies are rich in carbohydrate. According to Messiaen (1992), the higher the protein fat, ash content, the less the carbohydrate. Similar results have been reported by Chikwendu (2007) and Yusuf *et al.,* (2008). Biscuit is an energy food which is taken mostly in between meals by both young and old (Giwa and

Abiodun, 2010). Ekop *et al.* (2010) reported 13.08, 21.71, 22.70 and 24.90% dry weight for *G. lucens* (cricket), *H. meles* (yam beetle), *R. phoenicis* (palm weevil) and *Z. variegatus* (grasshopper), respectively. *M. nigeriensis* was also reported to contain 20.70% by composition of carbohydrate (Igwe *et al.*, 2011) while *C. forda* contains 54.30% by composition (Osasona and Olaofe, 2010). These insect species may not be desirable as a good source of carbo-hydrate as human adult need about 400 to 500 g carbohydrate intake as starch.

Mineral Composition of Wheat Cookies Enriched with Edible Termites

There were no significant differences in the mineral content of the cookie samples determined except in phosphorus. The mineral content increased as the percentage addition of *M. nigerensis* increased. According to Igwe *et al.*, (2011) *Macrotermes nigerensis* is a gregarious termite that is eaten as a delicacy in different part of Nigeria and several other African countries. They reported that the edible termites as a delicacy is a potentially rich source of nutrients, minerals, vitamins and unsaturated fatly acid that maybe necessary for combating protein energy related disease conditions prevalent in developing countries. Therefore, the inclusion of the edible termite into these staple enhance the nutritional quality in these diets. In addition magnesium is needed for more than 300 biochemical reactions in the body. It helps maintain muscle and nerve functions, keeps heart rhythm steady and supports a healthy immune blood and regulates blood sugar levels (Saris *et al.*, 2000). Lack of this mineral is a major problem in women and children diet in the developing world particularly among pregnant women and mainly in African (Orr, 1986). 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 (Talwar *et al.*, 1989).

Antinutritional Composition of Wheat Cookies Enriched with Edible African Termite

The levels of antinutritional factors found in the cookies are shown in Table 3.The values obtained appeared to be low and in reasonable agreement with those reported by commonly consumed food articles (Ezeagu 2005). Low levels of anti- nutritional factors such as tannins, saponins, phytate, and hydrogen cyanide have been reported in cookies produced from pigeon pea, cocoyam and sorghum flour blends (Okpala and Okoli, 2011). The saponin content of the cookie samples were very low suggesting that in this regard, they pose no threat to human consumption. Saponin has been reported to lower plasma cholesterol concentration (Topping *et al.,* 1980). Oxalates are known to sequester and precipitate some useful metallic elements, thus making them unavailable for absorption in human system (Groff *et al.*, 1995). The lethal dose of oxalate is between 200 and 500mg/100g (Pearson, 1963). Phytate, like oxalates limit the availability of some notable minerals like magnesium, iron and even calcium (Groff *el al.*, 1995). Phytic acid has also been implicated in the removal of phosphorus and causing indigestion and flatulence in human system (Ndubuakaku *et al.,* 1989). Onwuka (2005) reported that the presence of tannins can cause browning or other pigmentation problems in both fresh food and processed products. He also stated that tannins can provoke an astringent reaction in the mouth and make the food unpalatable and that they can complex with and thus precipitates proteins in the gut, reducing the digestibility or inhibiting digestive enzymes and micro organisms.

Organoleptic Properties of Wheat-Termite Cookies

The mean sensory scores for wheat cookies enriched with edible termites *M. nigerensis* are shown in Table 4. There were no significant difference in terms of the colour, texture and flavour of the cookie samples. Colour is a very important parameter in judging properly baked biscuits that not only reflect the suitable raw material used for the preparation but also provides information about the formulation and quality of the product (Abu-salem and Abou- Arab, 2011). Flavour is the main criteria that makes the product to be liked or disliked (Abu-Salem and Abou-Arab, 2011). The sensations of taste and smell are functions of flavour which is a complex of sensations (Iwe, 2007). Food flavour according to Ihekoronye and Ngoddy (1985) arises from a subtle interaction of taste and aroma, which imparts a pleasing and displeasing sensory experience to a consumer. It is the flavour of a food that ultimately determines its acceptance or rejection, even though its appearance evokes the initial response. There was significant difference in the taste of the cookie samples. The difference could be mainly due to maillard reaction which occurred during the baking process. Hence edible termite flour substitution at 5% wheat cookies was adequate for the product that would enjoy general consumer acceptance. However at higher edible termite flour supplementation varying significant difference occurs in comparison with the control at the probability level. The cookies with 20% edible termite substitution had the least scores in nearly all the quality attributes evaluated and it was unacceptable by the members of the panel in the hedonic scale rating for acceptability.

CONCLUSION

The present study was undertaken to develop a process of incorporating edible termites into baked food products (cookies) and evaluate the product's nutritional and sensory qualities. The wheat-termite cookies at 5 - 10% substitution were well accepted by the members of the panel signifying the great potential for large-scale production and commercialization of the insects in an effort to ensuring food security in Africa. The cookie samples enriched with *M. nigeriensis* have the potential of helping to address the problems of acute malnutrition and food insecurity plaguing the least developed countries. This can be achieved with the cooperation of all stakeholders in food security. It is highly recommended that production of cookie samples enriched with *M. nigeriensis* be consumed by both adult and infants due to its high protein content and minerals. Also further research should be carried out in order to determine the maximum shelf life of wheat cookies enriched with edible African termite and the prevalent microorganisms that affect them especially during storage. Furthermore public enlightenment, seminar is needed on the nutritional benefits of supplementation of flour with the larvae of *Macrotermes nigerensis* in the production of wheat cookies and other snack products.

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Table 1: Mean Proximate Composition of Wheat Cookies Enriched with Edible Termites *M. nigerensis*

	Samples					
Parameters	**AZ**	**AQ**	**AC**	**AP**	**AT**	**LSD**
%Moisture content	2.01±0.16	2.03±0.06	2.01±0.03	2.03±0.08	1.85±0.04	____
%Protein	9.05^{c} ±0.20	9.22^{c} ±0.51	11.31^{bc}±0.21	14.14^{ab}±0.16	15.69^{a}±0.28	3.66
% Ash	4.71±0.05	5.35±0.08	5.79±0.04	6.07±0.10	6.38±0.04	____
%Fat	9.14^{a}±0.16	9.79^{b} ±0.13	9.99^{c}±0.27	11.0^{c}±0.03	12.7^{d}±0.10	0.32
%Carbohydrate	63.37^{a}±0.17	66.78^{b}±0.27	70.89^{c}±0.36	72.92^{d}±0.28	75.09^{a}±0.13	0.48

Means in the same row with the same superscript are not significantly different at P<0.05.
The mean were separated using least significant difference (LSD) Fisher's test.

Key: AZ = 100% wheat flour (control)
AQ = 5% Edible termite + 95% wheat flour
AC = 10% edible termite + 90% wheat flour
AP = 15% edible termite + 85% wheat flour
AT = 20% edible termite + 80% wheat flour

Table 2: The mean Mineral Content of Wheat Cookies Enriched with Edible Termites *M. nigerensis*

Samples	Potassium mg/100g	Sodium mg/100g	Magnesium mg/100g	Calcium mg/100g	Phosphorus mg/100g
AZ	45.07±1.22	234.13±1.22	13.07±1.22	22.71±2.32	67.5 ± 0.52^{c}
AQ	44.53±0.46	232.27±1.67	12.8±1.39	22.71±2.32	67.77 ± 0.29^{bc}
AC	45.67±0.12	234.13±1.22	12.0±2. 40	25.39±2.32	67.93 ± 0.67^{bc}
AP	44.80±0.69	234.93±3.11	11.20±1.39	26.72±2.32	68.63 ± 0.46^{b}
AT	45.33±0.23	232.33±0.46	10.40±1.39	26.72±2.32	82.0 ± 0.35^{a}

Means in the same column with the same superscript are not significantly different at $P<0.05$.
The mean were separated using least significant difference (LSD) Fisher’s test.

Key: AZ = 100% wheat flour (control)
AQ = 5% Edible termite + 95% wheat flour
AC = 10% edible termite + 90% wheat flour
AP = 15% edible termite + 85% wheat flour
AT = 20% edible termite + 80% wheat flour

Table 3: Mean Antinutritional Values of Wheat Cookies Enriched with Edible Termites *(M.nigerensis)*

Samples	Oxalate (%)	Phytate (%)	Tannin (%)	Saponin (%)
AZ	0.064±0.01	0.066±0.00	0.071±0.00	0.11±0.01
AQ	0.05±0.01	0.0661±0.00	0.0621±0.00	0.09±0.01
AC	0.04±0.01	0.134±0.14	0.054±0.00	0.07±0.01
AP	0.04±0.601	0.048±0.00	0.044±0.00	0.05±0. 01
AT	0.027±0.01	0.044±0.00	0.034±0.00	0.04±0.00

Means in the same column with the same superscript are not significantly different at P<0.05.
The mean were separated using least significant difference (LSD) Fisher's test.

Key: AZ = 100% wheat flour (control)
AQ = 5% Edible termite + 95% wheat flour
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Table 4: Mean Sensory Scores of Wheat Cookies Enriched with Edible Termites, *M. nigerensis*

PARAMETERS	AQ	AC	AP	AT	AT	
Colour	5.9±1.97	5.35±1.89	5.60±1.31	4.95±2.24	4.7±2.45	______
Texture	5.3±2.05	5.2±1.91	5.75±1.25	5.75±1.86	5.15±1.76	______
Flavor	6.35±1.87	5.75±1.52	5.40±1.51	5.0±2.07	4.15±1.53	______
Taste	6.85^{a} ±2.52	6.05^{ab}±1.43	5.9^{b}±1.77	5.7 ^{a}±1.78	5.25^{a}±1.41	0.95
Gen. acceptability	7.2^{a}±1.51	6.8^{ab}±1.40	6.25^{ab}±1.25	6.2 ^{a}±1.36	5.15^{a}±2.35	0.97

Means in the same row with the same superscript are not significantly different at $P<0.05$.
The mean were separated using least significant difference (LSD) Fisher's test.

Key:
- AZ = 100% wheat flour (control)
- AQ = 5% Edible termite + 95% wheat flour
- AC = 10% edible termite + 90% wheat flour
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Reference to this paper should be made as follows: Ojinnaka, M.C., Ukah, N., and Okorie, S.U. (2015), Production and Quality Evaluation of Wheat Cookies Enriched with Edible African Termites *(Macrotermes Nigeriensis). J. of Biological Science and Bioconservation,* Vol. 7, No. 1, Pp. 55 – 73.