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Quality Evaluation of Biscuit Fortified with Edible Termite (*Macrotermes nigeriensis*)

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Edible termite (*Macrotermes nigeriensis*), a protein-rich insect is a good source of micro and macronutrients. Quality and acceptability of biscuits produced from wheat-termite flour were evaluated. Wheat flour was enriched with edible termite to produce biscuits with varying amount of termite (100:00, 95:05, 90:10, 85:15 and 80:20). Biscuits were evaluated for chemical composition, physical characteristics and the sensory attributes. The wheat-termite biscuits showed significant difference in their moisture (3.50 – 5.01%), ash (0.72 – 3.32%), fibre (0.74 – 3.35%), fat (0.23 – 5.07%), protein (9.80 – 17.07%) carbohydrate (85.48 – 68.35%) and energy (791 – 719%) contents. The results of the nutrient analysis showed that most of the values increased with the increase in the level of edible termite inclusion. However, the carbohydrate and energy values decreased with the level of inclusion of termite flour. The result of the physical characteristics showed that the diameter increased (5.39 – 5.72 cm) as the thickness decreased (0.63 – 0.52 cm). The spread ratio of the biscuit increased, ranging from 8.55 – 11.00. The break strength of the biscuit reduced with an increase in the level of termite flour inclusion, ranged from 283 – 259 g. The weight also increased from 12.58 – 16.90 g. The result also showed that 5% termite biscuit compared

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favourably with the control regarding aroma, colour and overall acceptability, it was the most generally accepted sample with the increased level of termite, followed by the sample with 20% termite inclusion. The study has revealed edible termite is an excellent source of nutrients necessary for combating protein-energy-malnutrition rampant in our world today.

Keywords: Edible termite; biscuit; chemical; physical; sensory.

1. INTRODUCTION

Food and nutrition security has been one of the world's most pressing concerns which are caused by an increase in population and is more prevalent in Africa [1]. Malnutrition has been a problem because many young and old are suffering from the insufficient or unbalanced diet. Biscuit is one of the confectionery products representing one of the most significant kinds of snack foods throughout the world which are widely consumed by individuals in all age groups [2]. It is one of the most desirable snacks for both young and adults because of its low manufacturing cost, more convenience and long shelf-life. Biscuit making is generally done from refined wheat flour of 60 to 75% extraction in which the major portion of minerals, vitamins, fibres found in the bran layer is partially or totally removed. This has significant effects on consumer's health if it is consumed heavily without supplementing with other foods rich in fiber, because dietary fiber is associated with various health benefits like lowering of cholesterol, glycemic index level, colon cancer, and bowel disorders and to improve lipid metabolism [3]. Among confectionery products, biscuit can serve as a vehicle for important nutrients. Earlier, many authors have used protein and fiber rich ingredients to improve the nutritional quality of biscuits [4-5] by partial substitution of wheat flour with defatted soybean or chickpea flours [6], oat, wheat, rice and barley bran [7], chickpea, broad bean and isolated soy protein [8].

For many years, edible insects contribute to the diet of different populations in the world. It is an important adjunct in the diet of many people in the tropics [9]. Edible termite (*Macrotermes nigeriensis*) is a winged adult termite which is a good source of protein, fiber and fat content (and thus energy); and many essential minerals and vitamins [10]. Therefore, the need for termite, an insect that has higher consumption affinity than other insects [11] and an inexpensive source of single cell protein, appreciable fiber, unique taste and other nutrients would be suitable to be incorporated into biscuit being a food universally consumed by all age groups, especially children. In the development of this, it will ease enriched and inexpensive product delivery to the consumers table and will, in turn, reduce the incidence of food security risk, improve health conditions of individual consumers and will also lend termite to more utilisation. On this note, this study was carried out to enrich biscuit with edible termite and to evaluate the effect of termite addition on some quality parameters of biscuit.

2. MATERIALS AND METHODS

2.1 Materials

The termite (*Macrotermes nigeriensis*) was harvested during the rainy season in May/June at Stadium Area, Ogbomoso, Oyo State, Nigeria while flour and other ingredients used for the work were obtained from a local market in Ogbomoso.

2.2 Preparation of Dried Termite

The harvesting of termite was done as termite warms emerge. Source of light (white bulb) was set up with water basins underneath to catch the termites as they drop. This lasted for about one hour. The termites were removed from the water, washed, drained and spread in trays. It was sundried until its wings break-off easily. It was de-winged. After this, the termite was milled and added to the wheat flour at different ratios (w/w).

2.3 Formulation of Wheat-Termite Flour Mixes

Wheat-termite flour was processed by blending wheat and termite in various proportions of 5, 10, 15, 20% of ground termite mixed with 95, 90, 85 and 80% of wheat flour, respectively. For control, 100% wheat flour was used for the biscuit sample.

2.4 Production of Biscuits

Biscuits were produced from the five formulations using the method of Oluwamukomi et al. [12] with slight modification. Formulated wheat-termite flour mixes (100%), sugar (20%), fat (27%), salt

(0.1%), and sodium bicarbonate (2.0%) were added to prepare the dough, and were continuously mixed until a smooth consistency was obtained. The dough was then kneaded, rolled out thinly on the cutting board where it was cut out into uniform shapes and sizes using a cutter. The cut dough was placed in a greased baking tray and transferred into the oven. The biscuit was baked at 200℃ for 10 min, cooled and packaged.

2.5 Determination of Chemical Composition of the Formulated Wheat-Termite Flour Mixes and Biscuits

The mixes and biscuit samples were analysed for moisture, total ash, crude fibre, fat, crude protein and carbohydrate (by difference) using standard methods of AOAC [13]. Energy value was also determined by AOAC [13] standard method. The caloric value (kCal/g) was calculated by multiplying the mean of crude protein and total carbohydrate by water factor of 4 each and that of crude fat multiplied by 9 and summing up the products as energy value.

2.6 Determination of Physical Properties of Biscuits

Weight and diameter of the biscuit were determined by weighing on a weighing balance and measuring with a calibrated ruler, respectively [14]. The spread ratio of the biscuit was determined using the method of Gomez et al. [15] by making three rows of the five well-formed biscuits, and the thickness was measured. The same biscuits were arranged horizontally edge to edge, and the sum diameter was measured.

$$Spead\ ratio = \frac{\text{diameter}}{thickness}$$

The break strength of the biscuit was determined according to Okaka and Isieh [16] method. Biscuit of known thickness was placed between two parallel wooden bars, weights were added until the biscuit snaps. The least weight that causes the breaking of the biscuit was regarded as the break strength.

2.7 Sensory Evaluation

The biscuit samples were presented to twenty (20) semi-trained panellists among staff and students of Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria. The panellists were familiar with the eating of biscuit. The biscuit samples were assessed for the following quality attributes; colour, crispiness, aroma, texture, taste and overall acceptability using a 7-point hedonic scale, where 7 = like extremely, 6 = like very much, 5= mildly like, 4 = neither like nor dislike, 3 = mildly dislike, 2 = dislike and 1 = dislike extremely.

2.8 Statistical Analysis

The data generated in triplicate were subjected to Analysis of Variance (ANOVA) to determine significant difference at 95% confidence level among the means. The means were separated with Duncan Multiple Range Test (DMRT) using Statistical Package for Social Sciences (SPSS) version 20.0.

3. RESULTS AND DISCUSSION

3.1 Chemical Composition of Formulated Wheat-termite Flour Mixes and Biscuit Produced

The results of the chemical composition of wheat-termite mixes are shown in Table 1. The results were found significantly different ($p<0.05$) from each other. The moisture (6.47-7.03%), ash (0.67-2.73%), fiber (0.88-3.20%), fat (0.21-8.86%) and protein (7.80-15.87%) increased as the inclusion of termites increased in the mixes which is due to the high content of those compositions in edible termites. The same trends were observed in the chemical composition of biscuits produced from varying proportions of wheat-termite flours as shown in Table 2. It was observed that there was a progressive increase in contents of moisture (3.50- 5.01%), ash (0.72-3.32%), fiber (0.74-3.35%), fat (0.23-5.07%) and protein (9.80-17.07%) as the termite content increased in the flour used. Meanwhile, carbohydrate and energy contents decreased as the termite content increased. According to Slavin [17] and Yusufu et al. [18], cookies with a high content of fiber and low carbohydrate content have health benefits such as reduced constipation and ease in colon digestion. The decrease could be a result of termite flour increase in the biscuit. The results agreed with the findings of Masoodi and Bashir [19] who fortified biscuit with flaxseed; Atobatele and Afolabi [20] who blended soybean and maize flour to make cookies; and Okoye and Obi [21] who also substituted wheat with African breadfruit for cookies.

3.2 Physical Characterisation of Biscuit

Table 3 shows the physical characteristics of biscuits from wheat-termite flour. Biscuits with wheat have physical characteristics that change with the incorporation of termite flour. The diameter increases with the increase in the inclusion of termite flour. The results of the diameter of biscuits from composite flour were found significantly different ($p<0.05$) from each other but the one from wheat with 5% inclusion was not significantly different from the control sample. Meanwhile, the reverse was experienced for the results obtained for thickness, in which thickness of biscuit decreased with increase in diameter. This was in agreement with the studies of Agu et al. [22] and Baljeet et al. [23] where incorporation of African breadfruit (*Treculia africana*) and buckwheat flour was done with wheat flour for biscuit making, respectively.

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The spread ratio of biscuits which is the ratio between the diameter and the thickness increases ranged from 8.56 – 11.00 with control sample having the lowest value. The spread ratio increased with increasing level of substitution with termite flour. Spread ratio is the most important parameter to assess the quality of biscuits [24]. Biscuits with high values of spread ratio are the best according to Eissa et al. [25]. The incorporation of termite flour in white wheat flour reduced gluten content and hence, reduced the elasticity of the pasta as well as the thickness of biscuits [26] which may be responsible for the increase in spread ratio with the increase in the level of substitution of termite flour. The termite flour had a high and positive effect on the spread ratio since its inclusion enhanced the spreadability of the biscuit samples.

The results of the breaking strength of biscuit samples from wheat-termite flour decreased as the level of substitution increased which ranged between 283 and 259 g. There is also a relationship between the spreadability, height (thickness) and the breaking strength. The thinner the biscuit, the lesser its ability to withstand stress/load. The increase in the inclusion of termite flour in the biscuit produced affected the ability of the biscuit to withstand stress. The use of composite flour for biscuit making has been reported by Okaka and Isieh [16] and Ayo et al. [14] to reduce its breaking strength.

3.3 Sensory Properties of Biscuit Samples

The sensory characteristics of biscuit from wheat-termite flour biscuits are shown in Table 4. The 100% wheat flour biscuit (control) was significantly ($p\leq0.05$) highest rated in all attributes except for colour and overall acceptability which have the highest values in 5% termite flour substitution. The trend of results of sensory attributes is similar to the findings of Masoodi and Bashir [19] in fortifying flaxseed with wheat flour in the production of biscuit. It also agrees with Kinyuru et al. [27] in wheat-buns production. There was no significant difference among all the samples regarding aroma and texture. Clarity of biscuits is partly due to the whiteness of the white wheat flour. Siddiqui et al. [28] found that the decrease in biscuits colour was related to the high level of proteins. The amino acids of proteins reacted with the reducing sugars during baking causing Maillard reaction. Increase in protein content affects the colour of biscuits; it becomes darker with protein increase [29]. Biscuit from 5% termite inclusion compared favourably with the control regarding aroma, colour and overall acceptability. The panel scores for crispiness and aroma decreased with increasing levels of substitution of wheat flour with termite flour. All the samples were generally acceptable, but the control and the sample with 5% termite flour inclusion were most preferred among the formulated biscuit.

Table 1. Proximate composition and energy content of formulated wheat-termite flour

Flour sample	Moisture (%)	Ash (%)	Fibre (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Energy (kCal)
100:0	6.47±0.13^{e}	0.67±0.02^{e}	0.88±0.04^{e}	0.21±0.14^{e}	7.80±0.17^{e}	84.38±1.43^{a}	791±1.4^{a}
95:5	6.68±0.12^{d}	0.96±0.06^{d}	1.02±0.07^{d}	2.31±0.19^{d}	11.11±0.25^{d}	78.56±1.09^{b}	770±1.7^{b}
90:10	6.81±0.06^{c}	1.86±0.08^{c}	1.50±0.04^{c}	4.59±0.39^{c}	12.73±0.23^{c}	73.34±1.45^{c}	749±1.9^{c}
85:15	6.93±0.04^{b}	2.28±0.14^{b}	2.58±0.05^{b}	6.74±0.46^{b}	14.84±0.19^{b}	68.39±0.87^{d}	730±1.2^{d}
80:20	7.03±0.08^{a}	2.73±0.10^{a}	3.20±0.09^{a}	8.86±0.59^{a}	15.87±0.02^{a}	62.54±1.58^{e}	719±0.8^{e}
Termite	8.59±0.50	6.61±0.26	5.30±0.07	12.10±1.39	36.37±0.51	33.9±0.65	548±0.4

Data are presented as means± standard deviation of triplicate determinations.
Values with different alphabet along same column are significantly ($p>0.05$) different
100:0, 95:5, 90:10, 85:15 and 80:20 are wheat-termite flour proportions

Table 2. Proximate composition and energy content of biscuit

Biscuit sample	Moisture (%)	Ash (%)	Fibre (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Energy (kCal)
100:00:00	3.50±0.07^{e}	0.72±0.02^{e}	0.74±0.04^{e}	0.23±0.15^{e}	9.80±0.10^{e}	85.48±2.67^{a}	809.44±1.9^{a}
95:05:00	4.15±0.16^{d}	1.26±0.13^{d}	1.13±0.06^{d}	1.43±0.22^{d}	11.72±0.17^{d}	80.92±0.32^{b}	785.88±2.2^{b}
90:10:00	4.76±0.11^{c}	2.33±0.10^{c}	1.89±0.05^{c}	2.74±0.49^{c}	14.30±0.41^{c}	75.02±0.87^{c}	753.34±1.2^{c}
85:15:00	4.91±0.03^{b}	2.90±0.03^{b}	2.79±0.12^{b}	3.89±0.67^{b}	16.54±0.25^{b}	70.77±2.02^{d}	733.65±2.2^{d}
80:20:00	5.01±0.03^{a}	3.32±0.18^{a}	3.35±0.07^{a}	5.07±0.69^{a}	17.07±0.04^{a}	68.35±1.65^{e}	723.71±2.7^{e}

Data are presented as means± standard deviation of triplicate determinations.
Values with different alphabet along same column are significantly (p>0.05) different
100:0, 95:5, 90:10, 85:15 and 80:20 are wheat-termite flour proportions

Table 3. Physical characterisation of wheat-termite biscuits

Sample	Diameter (cm)	Height (cm)	Weight (g)	Spread Ratio	Breaking Strength (g)
100:0	5.39±0.01^{d}	0.63±0.01^{a}	12.58±0.02^{e}	8.56±0.02^{e}	283±0.05^{a}
95:5	5.42±0.02^{d}	0.60±0.02^{ab}	13.40±0.02^{d}	9.05±0.03^{d}	277±0.08^{b}
90:10	5.58±0.03^{c}	0.58±0.02^{ab}	15.10±0.03^{c}	9.62±0.13^{c}	271±0.06^{c}
85:15	5.66±0.03^{b}	0.54±0.01^{bc}	16.20±0.03^{b}	10.48±0.06^{b}	265±0.27^{d}
80:20	5.72±0.01^{a}	0.52±0.03^{c}	16.90±0.03^{a}	11.00±0.03^{a}	259±0.01^{e}

Data are presented as means± standard deviation of triplicate determinations.
Values with different alphabet along same column are significantly (p<0.05) different
100:0, 95:5, 90:10, 85:15 and 80:20 are wheat-termite flour proportions

Table 4. Sensory characteristics of wheat-termite biscuits

Sample	Taste	Crispiness	Aroma	Texture	Colour	Overall acceptability
100:0	6.70±0.57^{a}	6.00±0.79^{a}	5.90±1.02^{a}	5.95±0.83^{a}	6.00±0.97^{ab}	6.40±0.68^{ab}
95:5	6.30±0.80^{ab}	6.00±0.89^{a}	5.85±1.14^{a}	5.65±0.88^{a}	6.10±0.79^{a}	6.50±0.69^{a}
90:10	6.10±0.91^{b}	5.80±1.36^{ab}	5.60±1.09^{a}	5.65±0.88^{a}	5.85±1.14^{ab}	6.20±0.77^{b}
85:15	5.90±0.97^{bc}	5.55±0.95^{b}	5.50±1.00^{a}	5.25±0.85^{a}	5.40±0.88^{b}	5.50±0.89^{c}
80:20	6.00±0.86^{bc}	5.45±0.88^{b}	5.40±1.05^{a}	5.55±0.83^{a}	5.55±0.76^{b}	5.85±0.88^{bc}

Each value represents mean score by 20 panelists
Values with different alphabet along same column are significantly (p<0.05) different
100:0, 95:5, 90:10, 85:15 and 80:20 are wheat-termite flour proportions

4. CONCLUSION AND RECOMMENDATION

Chemical and physical characteristics of wheat-termite biscuit observed in this study proved that edible termite (*Macrotermes nigeriensis*) has the potential to contribute the nutritional and physical quality of the biscuits. It can be used as a partial substitute for wheat in biscuit production up to 20% without affecting the quality of the biscuit made from it. Wheat-termite biscuits produced in this study generally had higher protein, ash, fibre and fat. Biscuit with 5% inclusion of termite was more preferable in terms of sensory attributes and overall acceptability. So, this study confirmed the possibility of termite inclusion in carbohydrate- rich foods to give products of acceptable quality. This study has revealed edible termite as an excellent source of nutrients because it can be used as a supplement in the biscuit production since it enhances crude fiber and protein that are necessary for combating malnutrition rampant in our world today. However, further study can be carried to determine the storage stability of biscuit from wheat-termite.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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