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Attribute of Fortified Bread Produced from Cassava flour and winged termite. (*Macrotermes nigeriensis*)

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Abstract-In the tropical economy, it has often been promoted to use cassava as a partial replacement for wheat flour in many bakery and pasta products. However, the deficiency in the protein of Cassava has made the need for supplementing with high-protein products. Thus, the effects of adding winged termite powder to cassava flour partially with 90% of wheat flour for bread production were investigated. Samples of 10% of the blends of cassava-termite bread used in the study are 95:5 and 90:10. 85:15, 80:20 and 75:25% cassava termite, respectively, while 100% wheat flour was used as control. According to the results, the relative moisture content of bread made from composite flour ranged from 10.01 to 12.00%, the protein content from 9.65% to 11.13%, the fat from 3.06% to 3.75%, the ash from 2.05% to 2.26%, the fiber from 2.07% to 2.63%, and the carbohydrate content from 69.86% to 70.66%. The mineral contents Fe, Ca, K, and P of the produced bread increased with increased incorporation level of winged termite flour. Functional characteristics varied from 92.14% to 98.25%, 10.88% to 15.35%, 9.67% to 10.32%, 0.61% to 0.74%, and 2.11% to 3.64%, respectively, for water absorption capacity, bulk density, solubility swelling power, and oil absorption capacity. While there were substantial differences in texture, taste, and appearance, the bread's flavor and general acceptance did not differ significantly (p>0.05). Sensory evaluation of the cassava termite bread indicated that the sample containing 75:25% CT/MP was the most acceptable. This finding indicates cassava flour might work well in place of wheat flour when making bread, and adding termite might enhance the nutritional value.

Keywords: Fortified bread; Cassava; Flying termite; Chemical and sensory properties

1.0 **Introduction**

Bread is a staple food consumed by most nations around the world. It is a fermented confectionery made mostly from wheat flour, water, yeast, and salt through mixing, kneading, proving, shaping, and baking. (Keerthana *et al.,* 2020: Oyinloye *et al.,* 2022). Consumption of baked goods that are ready to eat is rising steadily in Nigeria, and imported flour is frequently used to produce bread in Nigeria. (Oyinloye *et al.,* 2022; Garba *et al.,* 2023). Nigeria also cultivates other staple crops than wheat, including yam, sweet potato, cassava, and cereals used to make bakery goods. Therefore, substituting local indigenous crops other than wheat flour in manufacturing bread, such as cassava and termite, would be advantageous. Consequently, less reliance on wheat importation will increase the industrial use of local crops. (Oyinloye *et al.,* 2021; Oyinloye *et al.,* 2022)

One of the world's most important food and feed plants, cassava (Manihot esculenta Crantz), is a perennial woody shrub that grows in tropical and subtropical regions. Its edible root ranks fourth among staple crops, with an annual global production of around 160 million tons. (Murugesan *et al.,* 2020). Cassava can also grow under less-than-ideal circumstances; it can withstand drought stress and soil sterility and be stored underground for many months after maturation. (Azeta *et al.,* 2023). Nigeria routinely ranks as the world's top cassava producer, turning out more than 34 million tons of tuberous root yearly (Bergh *et al.,* 2019). In the southern agroecological zone, it dominates the rural economy. (Ema *et al.,* 2023; Bergh *et al.,* 2019). Cassava can be utilised in baking to the extent of 10%, in blend with wheat flour, according to studies conducted at the International Institute of Tropical Agriculture (IITA) in

Ibadan. Consequently, research has been done on composite flour containing protein-rich non-wheat flour, like edible termite flour, which is better for you nutritionally than wheat. (Wang and Jian 2022; Olagunju, 2019).

One of the most prevalent termite species (member of the family Termitidae) is the wingless termite (Macrotermes natalensis). According to acceptance and consumption, it is the most prevalent bug in Nigeria (Adeoye *et al.,* 2014). Winged termites, also called 'aku' in Ibo, 'chinge' in Hausa, and 'Esusu' in Yoruba, are common throughout Nigeria and appear annually at the start of the rainy season. The termites are suitable to be added to a particular staple food to improve its flavour and texture because they contain high-quality nutrients, including highly digestible proteins and minerals that are more bioavailable than minerals from plant foods (Ojha *et al.,* 2021; Oyinloye *et al.,* 2021).

2.0 **Materials and Methods**

2.1 **Sample collection**

The choice of edible winged termites (*Macrotermes* nigeriensis) for this study was made based on the species' reputed nutritional value, accessibility, and community preferences. Using traditional methods of attraction to light and handpicking, the adult winged termites were picked in the late-night hours during the rainy season (May to June 2023) from residential structures in Oyinloye Daniel Compound Pamo in Kwara state. Stored in the ice box before being transferred to the Department laboratory. The Federal Poly Ede.

2.2 **Sources of Materials**

Fresh cassava roots (*Manihot esculenta*) were procured from the Akoda market in the Ede junction, Osun State. Cassava roots were purchased from the Natural Root Crops Research Institute in Akoda Market, Ede, Nigeria and packed in a container to the lab for milling into flour to make bread. Ingredients such as table salt, blue band margarine, and baker's brand yeast were purchased from Oje Market in Ede, Osun State. At the same time, a different instrument and baking supplies were provided by the Department of Nutrition and Dietetics at The Federal Polytechnic, Ede.

2.3 **Processing methods**

The winged termites were washed three times with clean tap water to remove soil and dirt, de-winged, de-legged and blanched by soaking in boiled water for 2 min and drained before being subjected to oven drying at 45°C to constant weight. The dried insects were milled into a fine powder using an electric mill (BN-2001-62WCGermany). The processed termite powder was sieved using a 250 μm mesh sieve to fine brown powder, packaged in a labelled dry glass jar and stored in an airtight container until used for bread preparation. The collected cassava roots were cleaned, peeled, and rewashed with tap water to remove sand particles. They were cut into smaller pieces and oven-dried at 50°C to constant weight before being subjected to milling. The milled white powder was sieved to produce smooth, dried flour, which was stored in an airtight container until used, as shown in Figure 1

Preparation of cassava flour: Cassava flour was prepared from freshly harvested cassava roots. The roots were sorted and washed with clean water to remove soil and other foreign particle. It was peeled with a knife and re-washed. The peeled roots were then cut into chips and soaked in 0.1% sodium metabisulphite for 10-20 minutes to prevent browning. The chips were drained and oven-dried at 105°C for 3 hrs. Dried chips were cooled at room temperature (30°C ± 2°C) and were milled by attrition mill into a fine powder and sieved through a 60 mesh screen, packaged in a polyethene bag and stored for subsequent use as shown in Figure 2

The baking process of cassava-termite bread: Four different formulations of cassava-termite blend were 95:5, 90:10—85:15, 80:20, and 75:25% of cassava and termite, respectively. Bread from 100% wheat flour was also produced to serve as control. The bread was made on the blends using the standard bread-baking procedure established for the straight dough method (Saka *et al.,* 2021), as shown in Figure 3. In contrast, the details of ingredients used in the formulation were expressed as the percentage of the flour used: water, 43.6%; sugar, 8.3%; salt, 0.9%; milk, 2.3%; dried yeast, 0.4%; margarine, 16.6%; vanilla flavour 0.25.

Fresh Winged termite

↓

De-winged

↓

Blanching @ 50 ^{0}C for3 mins

↓

Oven drying @ 100 ^{0}C

↓

Grinding

↓

Sieving

↓

Package

↓

Storage

Figure 1 Flow chart for the preparation of winged termite powder
Source: Experiment 2023

Cassava roots

↓

Sorting

↓

Washing

↓

Peeling

↓

Re-washing

↓

Chipping

↓

Soaking (in Sodium metabisulphite)

↓

Draining

↓

Oven-drying (at 105^{0}C for 3 hrs.)

↓

Cooling

↓

Milling

↓

Screening

↓

Packaging

Figure 2 Flow chart for the preparation of cassava flour

Sources: Experiment 2023

Mixing of ingredients

↓

Pre-mixing of flour

↓

Mixing

↓

Proofing (1 ½ hours)

↓

Kneading

↓

Molding

↓

Panning

↓

Proofing (1hrs)

↓

Baking (250^{0}C for 30mins)

↓

Cooling

↓

Packaging

Figure 3 Flow chart to produce Bread.
Source: Experiment 2023

2.4 **Determination of proximate analysis**

The amounts of moisture, protein, fat, ash, and crude fiber were measured using the (AOAC method Amin *et al.,* 2019), and the amounts of carbohydrates were computed using the difference method. Carbohydrate = 100 − (% moisture + % protein + % fat + % ash + % crude fiber) (Godswill, 2019)

2.5 **Determination of mineral analysis**

AOAC determined iron, calcium, potassium and phosphorus (Amin *et al.,* 2019), the method using an Atomic Absorption Spectrophotometer (AAS) (Perkin-Elmer-Crop, Norwalk, model 560).

2.6 **Determination of functional properties**

Determination of bulk density: The procedure of (Misiats *et al.,* 2021) was employed to determine the bulk density of the samples. A 50 g flour sample was put into a 100 ml measuring cylinder. The cylinder was repeatedly tapped on a lab bench to maintain a constant capacity. It was noted what the model's volume was. Until there was no longer any volume change, the cylinder was repeatedly tapped against a table. Bulk density (g/cm3) = Weight of sample/Volume of sample after tapping.

2.7 **Determination of water absorption capacity**:

The Gu et al. (2020) procedure was followed. 1.0 g of samples were combined with 20 ml of distilled water and mixed quickly for 30 seconds. For 30 minutes, the mixture was allowed to stand at 30 °C. A 10 ml graduated cylinder was used to measure the supernatant produced. In g/ml, the water's density was calculated.

2.8 **Determination of swelling capacity and solubility index:**

The method described by Arukwe *et al.* (2021) was used with slight modifications. One gram of the flour blend sample was weighed into a 50-millilitre centrifuge tube. After adding it, 50 ml of distilled water was gradually incorporated. The slurry was heated for 15 minutes at various temperatures of 70°C, 80°C, 90°C, and 100°C in a water bath. The slurry was gently mixed throughout the heating to avoid flour clumping. The paste tube was whirled using a centrifuge for 10 minutes at 3000 rpm after 15 minutes. After centrifuging, the supernatant was immediately decanted. The sediment's weight was measured and noted. In order to calculate the dry matter content of the sediment gel, the moisture content of the gel was calculated.

$$\text{Swelling power} = \frac{\text{Weight of wet mass sediment}}{\text{Weight of dry matter in the gel}} \text{X100}$$

Solubility index (%) = Weight of dry solid after drying × 100

2.9 **Sensory evaluation**

The bread samples were subjected to organoleptic analysis within 24 hours of baking. The samples were evaluated by using a 20-mm trained panellist on a 9-point hedonic scale of 9 (like extremely) to 1 (dislike extremely) for appearance, texture, taste, crumb and overall acceptability Orhevba and Ndanaimi, (2021).

2.10 **Statistical analysis**

Using SPSS version 19.0, variance analysis was used to analyse the data, and Duncan Multiple Range Test procedures were used to determine the significance of the observed variations between means.

3.0 Results and Discussion

3.1 **Proximate composition of bread samples**

The proximate composition of cassava-termite bread samples and the control are shown in Table 1. The moisture content of the bread samples ranged from 10.01% to 12.00%. The highest percentage of moisture content was found in sample 75:25% bread, while the control samples had the lowest value. The differences in moisture content with bread having different termite levels are minimal, and these findings are similar to the result of Oyinloye *et al.* (2022). The difference between them is due mainly to different baking conditions, environmental issues, and moisture absorbability of the ingredient in different conditions.

As shown in Table 1, the crude protein content of the samples varied from 9.65% to 11.13%, with bread sample 75:25% of CF/TP, respectively, having the highest value, while the lowest value was recorded for the control (100%) wheat flour. An increase in the incorporation levels of termite powder into the flour blends increased the protein content of the combinations. This result agrees with those reported by Agu *et al.* (2020). No significant difference existed between the samples' crude fat, ash, and fiber. The values obtained for the samples' crude fat, ash and fibre increased progressively with the increase in the level of CF/TP.

The carbohydrate content of the bread samples was significantly increased as the amount of termite was reduced. The carbohydrate content increased from 69.86% to 70.66%, with the highest value obtained from the bread sample at 100%. The result obtained is similar to those reported by Amaechi *et al.* (2020)

3.2 **The mineral content of cassava-termite bread**

The mineral content results for bread produced using cassava termite flour are shown in Table 2. The mineral contents of iron, calcium, potassium, and phosphorus were gradually increased with the incorporation level of the CF/TP mixture compared with the control bread. The higher mineral composition obtained in the bread produced compared to the control (100% wheat flour) was due to the high contents of mineral salt found in termite (kolawole 2020)

3.3 **Functional properties of cassava-termite bread**

The Functional properties of cassava-termite bread are shown in Table 3. The water absorption capacity impacts the quality of baked items, claim Moiraghi et al. (2019). The four's protein content, particle size, and damaged starch somewhat influence them. As shown in Table 3, the water absorption capacity of the bread produced varied from 92.14% to 98.23%. Bread sample 85:15% of CF/TP, respectively, has the highest value, while the control has the lowest value. The Swelling power or capacity increased from 10.13% to 11.13%, with bread samples 95:5% having the lowest value. The association binding inside the starch granules and, apparently, the strength and nature of the micelle network as related to the flour's amylase concentration have been linked to the swelling power. High swelling power is produced by low amylose concentration (Shen *et al.,* 2019). The bulk density of the bread samples prepared from 85:15% and 80:20% of CF/TP did not differ significantly. At the same time, significant differences existed in the rest of the pieces. The irregular results are mainly due to the already compacted state of the models (in baked form), which show little or no difference in the determination of different samples.

Table 1 Proximate composition of cassava-termite bread

CF: TP	MOISTURE	PROTEIN	FAT	ASH	FIBRE	CHO
CONTROL	10.01^{d}	9.65^{d}	3.06^{c}	2.05^{d}	2.07^{d}	70.66^{a}
95.5	11.02^{c}	9.71^{c}	3.26^{c}	2.22^{b}	2.50^{bc}	70.55^{b}
90.10	11.38^{c}	9.76^{c}	3.56^{b}	2.20^{b}	2.46^{b}	70.46^{bc}
85:15	11.48^{bc}	9.82^{bc}	3.53^{b}	2.26^{a}	2.63^{a}	70.35^{cd}
80:20	11.76^{b}	9.99^{b}	3.61^{a}	2.26^{a}	2.47^{b}	70.25^{d}
75:25	12.00^{a}	11.13^{a}	3.75^{a}	2.13^{c}	2.63^{a}	69.86^{e}

Values with the same superscripts in the same column are not significantly ($p>0.05$) different.

CF: Cassava flour; TP: termite powder

Table 2 Mineral composition of cassava-termite bread.

CF: TP	Iron	Calcium	Potassium	Phosphorus
CONTROL	4.22^{e}	44.33^{d}	18.33^{e}	7.34^{d}
95.5	5.61^{d}	48.22^{c}	25.54^{d}	10.22^{c}
90.10	6.32^{c}	50.62^{c}	28.17^{cd}	10.33^{c}
85:15	6.21^{c}	52.21^{b}	33.33^{c}	11.32^{b}
80:20	7.22^{b}	52.32^{a}	36.42^{b}	15.24^{b}
75:25	7.43^{a}	53.61^{b}	37.46^{a}	17.55^{a}

Values with the same superscripts in the same column are not significantly ($p>0.05$) different.

Table 3 Functional properties of cassava bread with termite powder

CF: TP	WAC	BD	SWP	OAC	SOLUBILITY
CONTROL	92.14^{d}	0.61^{d}	11.13^{a}	9.34^{d}	3.64^{a}
95.5	97.35^{c}	0.69^{c}	10.13^{d}	10.32^{a}	2.23^{bc}

90.10	98.03[b]	0.72[b]	10.85[c]	10.23[a]	2.15[c]
85:15	98. 23[a]	0.64[c]	10.96[b]	9.92[b]	2.25[bc]
80:20	98.14[b]	0.64[c]	10.92[b]	9.87[c]	2.11[c]
75:25	98.18[a]	0.74[a]	10.88[b]	9.67[c]	2.35[b]

Values with the same superscripts in the same column are not significantly ($p>0.05$) different.

SWP: Swelling power; WAC: Water absorption capacity; OAC: Oil absorption capacity; BD: Bulk density

Table 4 Sensory properties of cassava bread with termite powder

CF: TP	TEXTURE,	FLAVOR	TASTE,	APPEARANCE,	OVERALL ACCEPTABILITY
CONTROL	7.71[a]	4.22[b]	4.58[a]	7.64[a]	6.43[a]
95.5	7.79[a]	3.11[d]	2.36[d]	4.56[c]	4.00[c]
90.10	6.64[b]	3.44[c]	1.37[e]	4.33[c]	4.67[c]
85:15	6.99[b]	4.11[b]	4.20[c]	6.44[b]	5.00[b]
80:20	6.71[b]	4.33[a]	4.73[a]	6.67[ab]	6.11[a]
75:25	6.36[c]	4.36[a]	4.51[a]	6.44[b]	6.22[a]

Values with the same superscripts in the same column are not significantly ($p>0.05$) different.

3.4 **The percentage of Solubility represents the proportion of the granules.**

This study recorded the highest solubility percentage in bread samples of 5% termite powder and the lowest in pieces of 25% termite. The Solubility decreased from 3.24% to 2.11%. This is caused by the proportion of starch granules higher in 5% termite bread than in other samples. Therefore, as the termite content decreased, the percentage solubility increased.

3.5 **Sensory evaluation**

The result of the sensory evaluation of the cassava-termite composite bread is shown in Table 4. Bread from sample 85:15% of CF/TP, respectively, was more acceptable regarding texture. There was no significant difference ($p>0.05$) between the flavour of the bread samples. As the incorporation level of termite powder increased, the flavour also increased. There were noticeable variations between the bread samples and the control in terms of both taste and appearance; the bread from selection 80:20% of CF/TP, respectively, had a better taste and look. The general acceptability of the bread samples showed no significant differences at ($p>0.05$) among the treatments. Among the samples (cassava/termite) bread, the highest overall acceptability was recorded, for example, 75% CF: 25% TP. As the termite content increased, the general acceptability could be deduced from the table. All the bread batches produced were accepted well with the control.

4.0 **Conclusion**

According to the study, African winged termites (M. *nigeriensis*) are an excellent source of proteins and other micronutrients crucial for preventing protein-energy malnutrition and micronutrient deficiencies currently rife throughout the poor world. The nutritional value of fermented cassava bread was increased by adding edible M. nigeriensis flour in various amounts. Regarding sensory qualities and consumer acceptability, cassava bread, with a 75:25% termite flour content, received the most favourable reviews in impoverished nations where cassava is considered a significant staple. Enriched cassava bread could be used to control the widespread nutrient shortage. To encourage the use of insects as food and widespread acceptance of such goods, additional research is required on such items' technological and safety aspects.

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