

**PROCESS DEVELOPMENT, NUTRITION AND SENSORY QUALITIES  
OF WHEAT BUNS ENRICHED WITH EDIBLE TERMITES  
(*Macrotermes subhylanus*) FROM LAKE VICTORIA REGION,  
KENYA**

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## ABSTRACT

Edible insects are an important source of nutrients. Edible winged termites (*Macrotermes subhylanus*), locally known as *agoro* in Lake Victoria region of Kenya, is an integral part of the diet in that region depending on seasonal availability and are traditionally consumed as a snack: raw, fried or sun-dried. The nutritional and economic value of the insect is often neglected and this study was geared towards encouraging their collection, utilization and commercialization. The present study was, therefore, undertaken to develop a process of incorporating edible termites into baked food products and evaluate the product's nutritional and sensory qualities. The study involved substitution of wheat flour with ground termite at proportions of 0%, 5%, 10% and 20% levels based on weight. Sensory attributes were evaluated using a mixed panel where half the panelists had a prior history of insect's consumption. The sensory attributes were evaluated on a 7-point Hedonic scale. The results showed that there was no significant difference ( $p>0.05$ ) in bun thickness (height) between the buns with 0% and 5% termite concentration. The scores for bun texture, aroma, taste and overall consumer preference were not significantly different ( $p\leq 0.05$ ) at 0% and 5% substitution. Differences in size, aroma and taste scores for the 5% bun and the 10% substitution were non-significant. Scores obtained at 20% level of substitution depicted lesser acceptability in all the attributes tested except for aroma, which scored above 5.0. In terms of consumer general acceptability, there was no significant difference ( $p>0.05$ ) between the control (0%) and 5% substitution with both scoring above 5.0 (like slightly). The 5% substitution showed a significant increase ( $p\leq 0.05$ ) in protein, retinol, riboflavin, iron and zinc contents to the extents of between 16% and 53% increase. The wheat-termite buns at 5% substitution were well accepted by the consumers signifying the great potential for large-scale production and commercialization of the insects in an effort to ensuring food security in Africa.

**Key words:** Termites, Process development, Nutrition, Sensory

## INTRODUCTION

Insects are an important food source for humans, and references to their nutritional value are found in a number of articles across a range of scientific disciplines [1,2,3]. Insects have played an important part in the history of human nutrition in Africa, Asia and Latin America [4]. There are more than 400 known species of edible insects [5]. In Africa, many species of insects have been used as traditional foods among indigenous people and have played an important role in the history of human nutrition. Insects were an equally important resource for the Indians of Western North America, who like other indigenous groups, expended much organization and effort in harvesting them [6].

*Macrotermes subhylanus*, simply called “Termite”, forms an important part of the food culture in the Lake Victoria region of East Africa. It is locally known as *agoro* in Luo language and *tiswa* by most *Luhya* sub-tribes. It is a gregarious insect most common during the rainy season. The alates are dark brown and are the largest of all types of alates [7]. At the onset of a rainy season, the winged reproductive fly off from their nest in large numbers. During this flight, known as the nuptial flight, pairs of male and female termites isolate themselves from the others and fall to the ground. Their wings then break off and each pair goes its own way to form a nest in a suitable spot. They begin by making a few tunnels in the ground. In a new nest, the male reproductive is the potential king and the female, the potential queen. In Lake Victoria region, when winged termites emerge in dense numbers, they are eagerly collected. They emerge with the first rains at the ends of the dry season when yields have not been much and presence of heightened food insecurity. The termite is usually attracted to sources of illumination at night and may be found, also, in the early hours of the mornings. The termites are harvested by placing a bowl of water under a light source. Attracted to the light they get trapped when they fall into the water. The communities in this region believe that the insect has a high nutritive value, so they tend to recommend it to their children and pregnant women. The insects are consumed raw although some processing is practiced. The usual steps in the processing of the insect include de-winging, frying and solar drying. They are usually consumed as part of a meal or as a complete meal with tapioca, bread, roast corn, ‘ugali’ or simply eaten as snack food.

Ordinarily, the termites are not used as emergency food during shortages, but are included as a planned part of the diet throughout the year or when seasonally available [8]. Therefore, considering the chronic or seasonal shortage of vertebrate food reserves in sub-Saharan Africa, utilization of insects, as an alternative food source on a wide scale should be encouraged. Food supplies in many countries in Africa are also inadequate in quantity and quality, contributing to the widespread malnutrition on the continent [5, 9].

Consumption of termites could be greatly enhanced if they were brought into the human diet using modern and improved preservation and processing methods.

The current traditional method of frying and sun-drying for termites' preservation and consumption is likely to face a lot of quality and consumer acceptability problems. High post-harvest losses are also likely to be experienced due to the heavy rains in the harvesting season. Sometimes the rainy season is prolonged, thereby preventing effective and quick drying. Post harvest losses and product spoilage due to hydrolysis and auto-oxidation of fats and proteolysis of proteins can be very common. As a result, the end product will be of poor quality with an unpleasant taste, hence contributing to low acceptability and sales especially to regions outside Lake Victoria.

The objectives of this study were, therefore, to develop a process of incorporation of termites into baked food products and evaluate the products' nutritional and sensory qualities. It is envisaged that the results would inform the efforts to availability of termite products and termite contribution to food security.

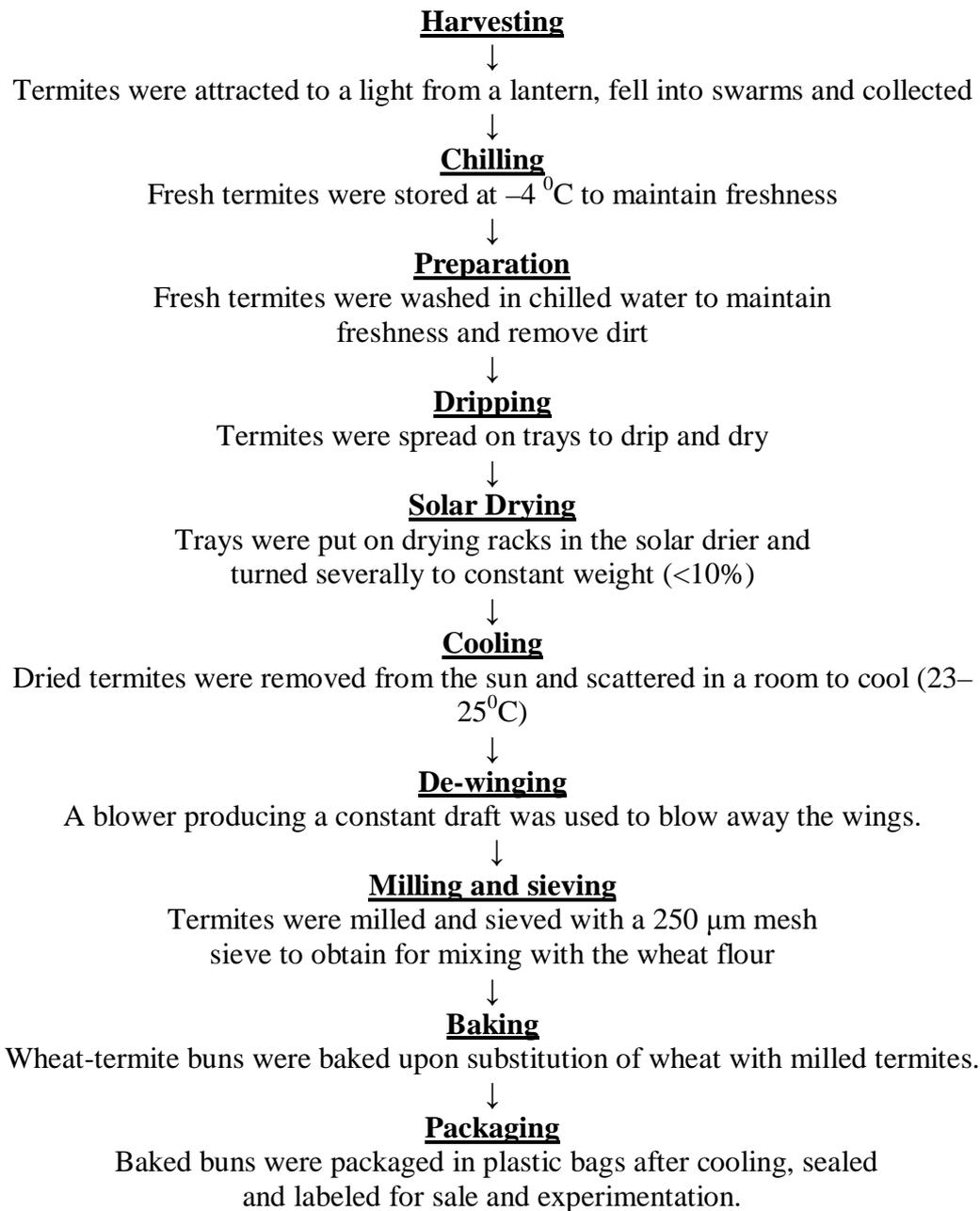
## MATERIAL AND METHODS

### Sample collection

The termites (*Macrotermes subhylanus*) were collected from the fields of five villages in Kanyaboli Sub-location of Siaya District along the Lake Victoria region of Kenya namely Urembo, Uradi, Wang' Chieny, Nyaseda and Liganwa. The insects collected were available at the time of fieldwork during the short rains season from March through May. Termites were attracted by light from a lantern lamp causing them to fall in large swarms that were collected and put in a clean container. The samples were stored in cool boxes with dry ice and transported to the Food Processing Workshops, Jomo Kenyatta University of Agriculture and Technology (JKUAT) for processing within 12 hours of collection. The processing commenced immediately upon arrival in the laboratory. Taxonomic identification of the insect species was done by an entomologist at Maseno University.

### Process development

The termites were sun dried using a solar drier at the Biomechanical and Environmental Engineering Department at Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya. The drying temperature was approximately 30°C with a relative humidity of approximately 40% and the insects were dried until the moisture content was below 10%. Wheat-termite buns were developed with substitution of the wheat flour with the dried and ground termite at 0%, 5%, 10% and 20% substitution this being the highest allowable limit for substitution of wheat in baked products. Baking was done by weighing 60 grams of the dough and the baking procedure followed according to AACC (1995) [10] method. The processing procedures for wheat-termite buns were developed as shown in Figure 1.



**Figure 1: Processing procedure for wheat-termite buns**

### Nutrient analysis

The baked buns were analyzed for moisture, ash, proteins, fat, calcium, zinc and Iron contents according to AACC (1996) [11], riboflavin, niacin [12] and retinol [13] using High-performance Liquid Chromatography.

### Sensory analysis

Sensory evaluation of the wheat-termite buns in relation to aroma, taste, appearance, texture and overall consumer preference were carried out using a 7-point hedonic scale (1—dislike extremely to 7—like extremely) with equivalent intervals between the categories used. The sensory evaluation panel comprised of twenty five panelists selected from the Food Science department of Jomo Kenyatta University who are familiar with sensory evaluation of foods. Half of the team comprised of people from the communities that eat insects.

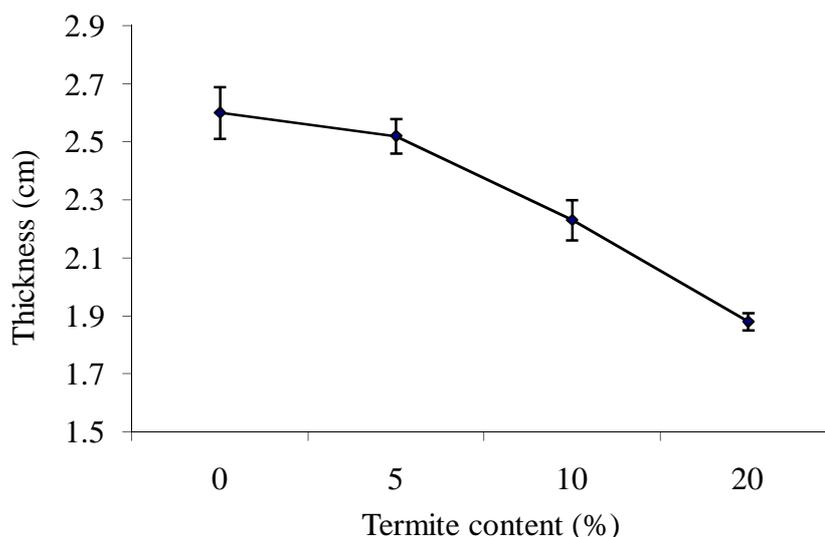
### Data analysis

Data were subjected to statistical analysis using SAS software [14]. Analysis of variance with multiple comparisons using Turkey's studentized range test was used to determine the significance of differences among treatments. The level of significance was set at  $p < 0.05$ .

## RESULTS

### Thickness (Height) of developed buns

The results showed that the thickness of the buns varied depending on the percentage of termite in the composite flour (Figure 2). It reduced with increase in termite's concentration.



**Figure 2: Change in thickness (height) of the buns with increasing wheat substitution**

There was no significant difference ( $p>0.05$ ) in thickness between the buns with 0% and 5% termite concentration but the buns containing 10% and 20% were significantly different from the control at the same level of significance. Similar results on decrease in product size/volume (thickness) have been reported on incorporation of non-gluten flour in wheat-baked products [15].

### **Sensory evaluation**

The sensory attributes of wheat-termite composite buns are presented in Table 1. Taste panel ratings of sensory properties of the bun samples decreased significantly ( $p\leq 0.05$ ) with increased contents of termite concentration in the composite flour. For the control (0%) and composite up to 5% of termite, the scores for bun texture, aroma, taste and overall consumer preference were not significantly different ( $p\leq 0.05$ ). However, the size and color were significantly different ( $p\leq 0.05$ ). Differences in size, aroma and taste scores for the 5% bun and the 10% substitution were non-significant. Scores obtained at 20% level of substitution were less acceptable in all the attributes tested except aroma which scored above 5.0. In terms of consumer preference, there was no significant difference ( $p>0.05$ ) between the control (0%) and 5% substitution with both scoring above 5.0 (like slightly). The two bun samples were therefore selected for nutrient composition analysis based on their high consumer preference.

### **Nutrient composition**

The nutritional content of the wheat-termite buns was evaluated and the results are shown in Table 2. There was a significant increase ( $p\leq 0.05$ ) in the nutrients content evaluated except calcium, which was not significantly different ( $p>0.05$ ). The buns showed a significant increase ( $p\leq 0.05$ ) in protein content on substitution with a 47.5% increase from the buns without wheat substitution. Retinol was not detected in the unsubstituted bun (0% termite) however, the developed bun was found to contain retinol ( $0.1\mu\text{g/g}$ ) thus the increase was assumed to be 100%. There was an increase in calcium content in the substituted wheat bun (5% substitution), though the increase was not found to be significant ( $p>0.05$ ). There was an over 10% increase in most nutrients assessed with riboflavin and iron recording an over 50% increase, except calcium which recorded an 8.3% increase.

### **DISCUSSION**

The use of wire mesh racks or trays for dripping and drying purposes improved the acceptability of the product since there was little contamination with foreign bodies such as sand and filth particles. Normally the termites are dried on the ground and this lead to contamination with foreign materials. The wings detach upon drying making it easy to blow them off. This further improves the appearance of the final product. Traditionally, the termites are consumed as raw, fried or sun dried. The developed process therefore adds variety in the mode of utilization of the insects thus creating more economic opportunities to the local communities as well as more avenues to fight malnutrition.

The developed process gives an improvement to the existing modes of processing and utilization of termites. It was evident that the process gave a clean product whose quality could be controlled. The drying process was also controlled thus only properly dried termites were utilized for processing. The technology is easy to adopt both at small scale and large scale as it requires local materials and the machinery can be easily fabricated. However this will come with some investment as one might have to acquire a solar drier. However, local fabricators can be contracted to make solar driers at affordable costs.

Increase in size is a function of the gluten content in the wheat flour and therefore reducing it has an effect on the size of the product [15]. Increase in thickness is as a result of the ability of the dough to hold gas produced from the fermentation within the dough. The gas leads to formation of void spaces (crumb cells) in the product after baking. In a wheat product the crumb cells should be even in size and evenly distributed within the product [15]. This was observed in the control product (0%). However, as the termite concentration increased, there was an increase in unevenness of the void spaces and this contributed to compromised product acceptability.

The substitution reduced the gluten content, which in turn reduced the size of the buns. The color of the buns darkened with increase in termite concentration and at 20% substitution, it was least acceptable to the consumer. During baking, Maillard reactions occur among sugar and the amino acids, peptides or proteins from other ingredients in the baked products, causing the browning [16]. The intense brown color was observed with the increase in termite concentration meaning an increase in protein content. The Maillard reactions also result in the taste and aroma associated with the baked products [17, 18]. This may explain the average score in aroma and taste on 20% substitution which is higher compared to other attributes.

The developed wheat termite buns with 5% termite concentration were found to contribute significantly to the recommended daily intake of the specific nutrients analyzed. They were shown to provide 34.7% of the protein RDI on consumption of 100g of the product per day [19]. They were also found to provide RDI values of 0.1% retinol, 6.53% niacin, 34.7% riboflavin, 15.0% iron and 21.5% zinc for a male adult [19]. The buns were therefore found to be a rich source of nutrients especially those that are of public health concern.

## CONCLUSION

The process developed for production of wheat-termite buns could easily be adopted for local production. By substituting a portion of wheat with dried powdered termites, nutritional composition of the composite buns is enhanced and bun made from a 5% substitution was comparable to the control in many sensory attributes. These results showed that a 5% wheat substituted for termite composite flour bun is potentially a viable product which is richer nutritionally and generally

acceptable. This study shows that the insect is an important food item that needs industrial application and commercialization and programmes geared towards achieving this objective will be a huge step towards fighting malnutrition and poverty in the Lake Victoria region and beyond.

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**Table 1: Mean score for sensory attributes on a 7-point hedonic scale**

Termite content (%)	Attribute					
	Size	Color	Texture	Aroma	Taste	Consumer preference
0.0	6.3±0.1 <sup>a</sup>	6.6 ± 0.1 <sup>a</sup>	6.2 ± 0.2 <sup>a</sup>	5.6 ± 0.2 <sup>a</sup>	5.4 ± 0.2 <sup>a</sup>	5.9 ± 0.2 <sup>a</sup>
5.0	5.4±0.1 <sup>b</sup>	5.8± 0.2 <sup>b</sup>	5.6 ± 0.2 <sup>a</sup>	5.4 ± 0.2 <sup>ab</sup>	5.5 ± 0.2 <sup>a</sup>	5.7 ± 0.1 <sup>a</sup>
10.0	5.1±0.2 <sup>b</sup>	4.5 ± 0.3 <sup>c</sup>	4.3 ± 0.2 <sup>b</sup>	4.9± 0.2 <sup>bc</sup>	4.9 ± 0.2 <sup>a</sup>	4.9 ± 0.2 <sup>b</sup>
20.0	2.9± .3 <sup>c</sup>	2.9 ± 0.3 <sup>d</sup>	3.4 ± 0.3 <sup>c</sup>	4.6 ± 0.2 <sup>c</sup>	5.0 ± 0.3 <sup>a</sup>	4.2 ± 0.3 <sup>c</sup>

Values in the same column followed by the same letter are not significantly different (p>0.05)

No. of panelists = 30

**Table 2: Nutrient composition of the developed wheat-termite buns**

Parameter	Non substituted termite)	(0% Substituted (5% termite)
Protein (%)	10.60 ± 0.90 <sup>b</sup>	15.63 ± 1.24 <sup>a</sup> (47.5)
Retinol (µg/g)	nd	0.10 ± 0.00 <sup>a</sup> (100.0)
Riboflavin (mg/100g)	0.17 ± 0.01 <sup>b</sup>	0.26 ± 0.07 <sup>a</sup> (53.0)
Niacin (mg/100g)	0.90 ± 0.10 <sup>b</sup>	1.11 ± 0.17 <sup>a</sup> (23.3)
Folic acid (mg/100g)	0.30 ± 0.01 <sup>b</sup>	0.33 ± 0.01 <sup>a</sup> (10.0)
Calcium (mg/100g)	10.00 ± 1.00 <sup>a</sup>	10.83 ± 0.02 <sup>a</sup> (8.3)
Iron (mg/100g)	1.20 ± 0.10 <sup>b</sup>	1.80 ± 0.22 <sup>a</sup> (50.0)
Zinc (mg/100g)	2.78 ± 0.60 <sup>b</sup>	3.23 ± 0.29 <sup>a</sup> (16.0)

Values are mean ± SE on dry weight basis

nd- Not detected

Values on the same row followed by the same letter are not significantly different (p>0.05)

Values in brackets indicate percentage increase in parameter on substitution n=6

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