



East African Journal of Agriculture and Biotechnology

ejab.eanso.org

Volume 6, Issue 1, 2023

p-ISSN: 2707-4293 | e-ISSN: 2707-4307

Title DOI: <https://doi.org/10.37284/2707-4307>

ENSO

EAST AFRICAN
NATURE &
SCIENCE
ORGANIZATION

Original Article

Food Safety Awareness and Practices Among Vendors and Consumers of *Macrotermes subhyalinus*

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Article DOI : <https://doi.org/10.37284/ejab.6.1.1549>

Date Published: **ABSTRACT**

03 November 2023

Keywords:

*Edible-Winged
Termites,
Food Safety Awareness,
Hygiene Practices,
Contamination.*

Edible-winged termites in Kenya, especially in Kakamega County, are widely consumed and offer an opportunity for food security and income generation during the swarming season. However, the processing and marketing of termites lack scientific evidence on food safety and hygiene, leading to potential contamination. This study was conducted to establish food safety awareness among termite vendors and consumers in Kakamega County. Data was collected through questionnaires and assessment tools, and the results showed that 98% of respondents consume termites, with the majority having secondary-level education and farming as their main occupation. The study revealed that the consumption of raw termites poses more risks compared to cooked termites. Moreover, inadequate food safety practices were observed among vendors, such as lack of handwashing, proper wear, and clean preparation surfaces, which exposes consumers to health risks. The study recommends educating stakeholders in the termite value chain on food safety and hygiene practices and enforcing food safety policies by the government to achieve food safety.

APA CITATION

Barasa, D. M., Alice, N. & Angira, C. H. O. (2023). Food Safety Awareness and Practices Among Vendors and Consumers of *Macrotermes subhyalinus*. *East African Journal of Agriculture and Biotechnology*, 6(1), 422-438. <https://doi.org/10.37284/ejab.6.1.1549>

CHICAGO CITATION

Barasa, Denver Masidza, Nakhumicha Alice and Charles H. O. Angira. 2023. "Food Safety Awareness and Practices Among Vendors and Consumers of *Macrotermes subhyalinus*". *East African Journal of Agriculture and Biotechnology* 6 (1), 422-438. <https://doi.org/10.37284/ejab.6.1.1549>

HARVARD CITATION

Barasa, D. M., Alice, N. & Angira, C. H. O. (2023) "Food Safety Awareness and Practices Among Vendors and Consumers of *Macrotermes subhyalinus*", *East African Journal of Agriculture and Biotechnology*, 6(1), pp. 422-438. doi: 10.37284/ejab.6.1.1549.

IEEE CITATION

D. M. Barasa, N. Alice & C. H. O. Angira "Food Safety Awareness and Practices Among Vendors and Consumers of *Macrotermes subhyalinus*", *EJAB*, vol. 6, no. 1, pp. 422-438, Nov. 2023.

MLA CITATION

Barasa, Denver Masidza, Nakhumicha Alice & Charles H. O. Angira. "Food Safety Awareness and Practices Among Vendors and Consumers of *Macrotermes subhyalinus*". *East African Journal of Agriculture and Biotechnology*, Vol. 6, no. 1, Nov. 2023, pp. 422-438, doi:10.37284/ejab.6.1.1549.

INTRODUCTION

The consumption of insects as a supplementary or alternative source of high-value protein has been a long-standing practice since antiquity. Globally, over two billion people consume around 2000 species of edible insects, primarily in tropical countries (Van Huis et al., 2013). The demand for animal protein is projected to rise by 76% globally from 2005 to 2050, especially in developing countries like Kenya, due to food scarcity caused by climate change, population growth, limited production factors, and increased demand for animal protein and its products. To address these challenges, sustainable food production systems, including edible insects, are being explored as potential solutions. In Kenya, edible-winged termites (EWT) are widely consumed, particularly in the Western region, and serve as an integral part of the diet in Kakamega County. However, EWT's seasonal nature, high perishability, and limitation due to environmental degradation impact their commercialization. Ensuring the safety of edible insects, including winged termites, is crucial to their widespread adoption, and there is need for food safety awareness and proper handling practices among vendors and consumers (Rumpold & Schlüter, 2013; Banjo et al., 2006).

Food hazards pose significant challenges to producers, food safety authorities, and consumers of edible insects, as common food-borne pathogens have been isolated in wild-harvested insects (Nganga et al., 2019; Belluco et al., 2015; Braide et al., 2011). In Kenya, food-borne illnesses result in a considerable number of deaths annually, emphasizing the importance of preventive measures and proper food safety regulations (Blazar et al., 2010). Despite the nutritional, environmental, cultural, and economic benefits of termites, their commercialization and inclusion in human diets remain limited in Kakamega County. The study aims to establish food safety awareness and current practices among termite vendors and consumers in Kakamega County to facilitate the approval and utilization of edible winged termites in Kenya

Study Objectives

This study is guided by four objectives whereby there is one overall objective and three specific objectives

Overall Objective

To establish food safety awareness and practices among winged termites' vendors and consumers

Specific Objectives

- To determine food safety awareness among edible winged termite vendors and consumers in Kakamega County.
- To examine food safety practices among vendors and consumers when handling edible winged termites.
- To identify related drivers and barriers affecting the food safety of edible winged termites

Research Questions

- What is the level of food safety awareness among edible termite vendors and consumers in Kakamega County?
- What are the current food safety practices among vendors and consumers when handling edible winged termites?
- What are the related drivers and barriers affecting the food safety of edible winged termites?

MATERIALS AND METHODS

Study Site

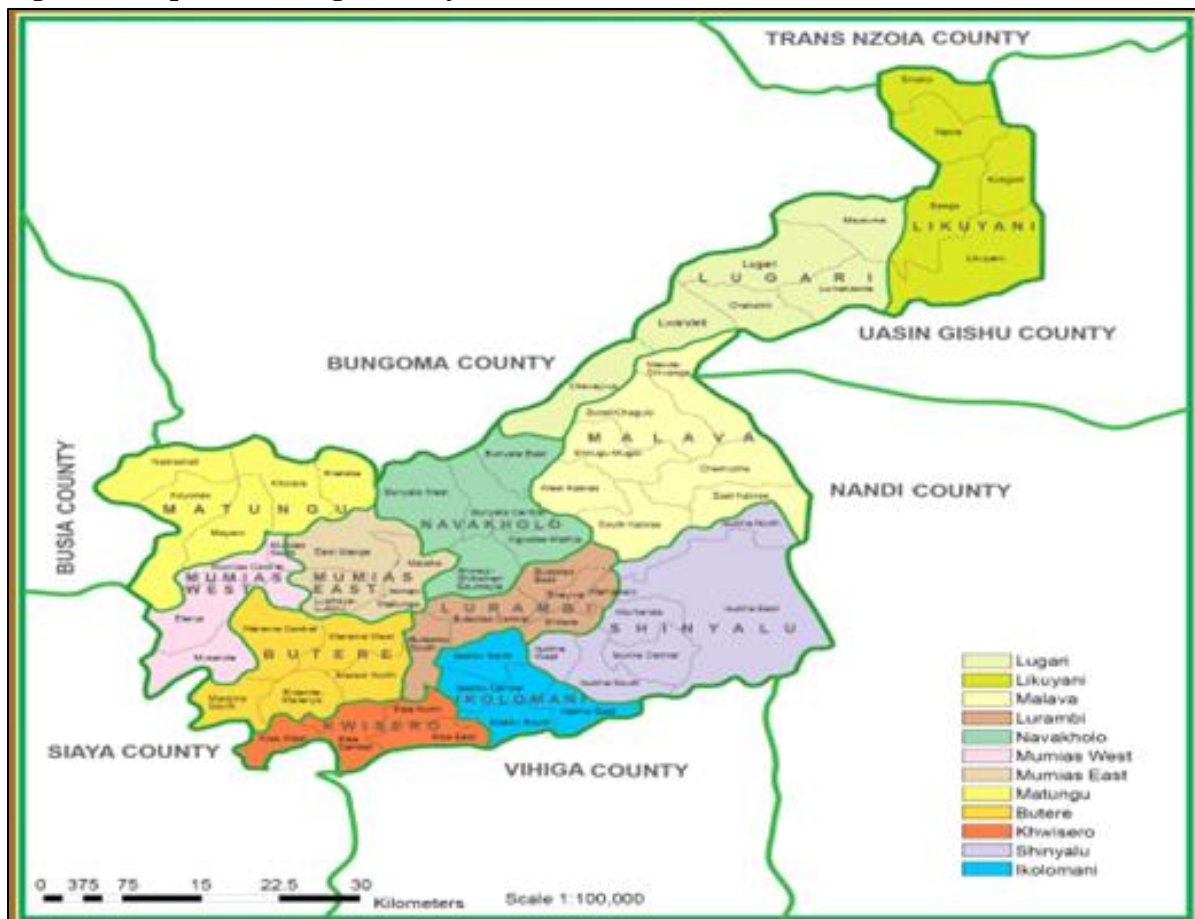
Kakamega County is bordered by Vihiga, Uasin Gishu, Nandi, Bungoma, Busia, Trans Nzoia, and Siaya Counties and covers an area of 3,033.8 km², with an altitude ranging from 1,240 to 2,000 meters above sea level. The climate in the area is predominantly tropical, with variations influenced by altitude and features like the Kakamega Forest. The region receives bimodal rainfall, averaging between 1250 to 1750 mm per year, and experiences temperatures ranging from 10.5 – 25.5°C, with the hottest months being January to

March and the coldest in July and August. These conditions create a favourable environment for agricultural practices in the area.

As of the 2019 census, Kakamega County had a total population of 1,867,579 people, residing in 433,207 households with an average size of 4.3 persons per household. With a population density of 618 people per square kilometre, Kakamega is the fourth-most populous county in Kenya. The majority of land ownership is individual, with

some portions held by cooperatives. Agriculture, encompassing crop farming and livestock rearing, forms the primary economic activity in the region. Maize, beans, sugarcane, millet, cassava, and sorghum are the main crops grown, while cattle, sheep, goats, and poultry constitute the major livestock. However, most rural households rely on rainfed agriculture, leading to hand-to-mouth living standards. Access to social amenities like piped water and electricity remains limited for many residents in the county.

Figure 1: Map of Kakamega County



Source: <https://kakamega.go.ke/download/map-of-kakamega-county/>

Research Design

This research used a descriptive survey design, administered to a selected sample of vendors and consumers in Kakamega County. The survey involved the use of personally administered questionnaires and observation as data collection tools. These designs are frequently used for descriptive study, as evidenced by Labovitz and Hagedorn (2006).

Target Population

Mugenda and Mugenda (2003), described target population as a group of objects or items or people from which samples are taken for measurements. The target population of this study comprised vendors and consumers of edible winged termites in Kenya.

Study Population

EWT vendors found in open-air markets or by the roadside and consumers of edible winged termites in Kakamega County. The study also targeted key informants comprising of village administrators, and elders in the study area.

Inclusion and Exclusion Criteria

- **Inclusion criteria:** Subjects involved in the study were termites' vendors and consumers who were willing and agreed to participate in this study. EWT vendors and consumers within the study spoke either in English, Kiswahili, or Luhya.

- **Exclusion criteria:** EWT vendors and consumers who were unwilling to partake in the study were ineligible for this study.

Sample Size Determination

The study population consisted of vendors and consumers of edible winged termites in Kakamega County. Lurambi (Kakamega Central), Likuyani, and Khwisero Sub Counties were purposively selected. This is because of the large numbers of vendors and consumers and open-air markets for termites. The approximated population sizes per the three Sub Counties according to the Kenya National Bureau of Statistics (KNBS, 2019), are as in *Table 1* below.

Table 1: Population Size

| Sub-County | Population Size |
|----------------------------|-----------------|
| Lurambi (Kakamega Central) | 188,212 |
| Likuyani | 152,055 |
| Khwisero | 113,476 |
| Total | 453,743 |

Data on consumption distribution per sub-county was unavailable. Thus the estimation of the population by the EWT was not done. Therefore, this study adopted the results of Koffi-Niaba et al. (2012) in Cote d'Ivoire who reported that 97% of respondents had consumed termites.

Calculations

$$N = 0.97(453743)$$

$$N = 440,131$$

The sample size of termite vendors and consumers was determined using the Yamane T. (1967) formula.

$$n = \frac{N}{1 + N(e)^2}$$

Where n= sample size, N= study population and e= margin of error.

$$n = \frac{440131}{1 + 440131(0.08)^2} = 156$$

Sampling Procedure

In this research, a systematic and random sampling approach was employed to choose respondents for the interviews through structured

questionnaires. This method allows for the gathering of targeted information while being efficient and cost-effective. The study covered 20 wards within the three sub-counties of Lurambi, Khwisero, and Likuyani. To achieve the calculated sample size of 156 respondents, at least six participants and two key informants were randomly selected from each ward, with preference given to areas where termite is sold. The use of simple random sampling ensured a representative sample, based on a probabilistic criterion, and provided an equal opportunity for each individual to be selected.

Data Collection Procedure

Village elders and chiefs were used to identify the key informants who could participate in the survey to provide desired information on the subject. Three data collectors were trained and used to administer interviews using well-formulated questionnaires in the ODK collected in each sub-county. An Android phone installed with the ODK Collect app was used by each enumerator.

Face-to-face interviews with a structured questionnaire sought direct information about the food safety awareness level of termites and the drivers and barriers to food safety termites for the first and third objectives. For the second objective, a food assessment observation tool was administered to EWT vendors to determine their adherence to essential food safety and hygiene as defined by the HACCP Food Safety Checklist. The checklist was to collect information on personal hygiene, food handling practices, and the vending surroundings.

Data Collection Tools

This study employed various data collection methods to achieve its objectives. Data was sourced from interviews, structured questionnaires, key informant guides, and direct observation.

Questionnaires

The questionnaire was carefully crafted in English and Kiswahili languages and then integrated into the Open Data Kit (ODK) app for data collection by enumerators. It comprised structured and closed-ended inquiries, divided into four sections. The first section focused on socio-demographic aspects, such as gender, age, marital status, and education level. The second section delved into the consumption patterns of edible winged termites, exploring areas like termite species preference, their availability, preferences, and prohibitions, as well as the frequency of termite consumption. Additionally, respondents' knowledge about termite abundance and distribution was assessed. The third section addressed the awareness of food safety concerning edible-winged termites. Questions in this section probed respondents about hygiene, safety, and quality standards during the collection/harvesting, processing, distribution, preparation, and consumption stages. Finally, the questionnaire investigated the drivers, activities, and environmental factors that promote the safety of edible termites, alongside the barriers/challenges that hinder attainment of food safety standards for EWT. It is important to note

that most questions in the questionnaire were structured and required close-ended responses.

Observation

An observation checklist was used to gather practical aspects of food safety such as personal hygiene, termite preparation, handling, and storage. This gave an actual picture of the participants' responses and ground information. This tool helped record accurate information and first-hand experience. An observation assessment tool for food safety practices was assigned to EWT vendors to determine their adherence to food safety requirements as outlined by the HACCP Food Safety Checklist. A checklist with a 5-point hedonic scale was administered across the food safety requirements.

Key Informant Interview Guide

This was used to collect data primarily for triangulating information received from the study sample on food safety awareness of EWT and the drivers and barriers to food safety of EWT vendors and consumers. It was administered to various village elders and administrators. The key informants helped identify the main issues affecting the achievement of food safety of edible termites in the study area and the key players in the value chain.

Pretest Study

A pre-tested questionnaire was administered to a few respondents to test the accuracy and objectiveness of the questionnaire. Corrections and adjustments were made before kick-starting. This assessment included checking the achievability of this study's objectives and the suitability of research tools. The pre-tested questionnaire was administered in sampled open-air markets in Kakamega County with the researcher's supervision.

Validity of the Research Instruments

A pilot study was conducted before the actual study to ensure the reliability and validity of the questionnaire. Additionally, the most appropriate time of study and sampling method was applied. There was also no coercion on respondents by the

different interviewers which minimized subjectivity. Finally, the entry of data was performed in a spreadsheet, and analysis was carried out using IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp

Data Analysis

Collected data was uploaded into an excel sheet, cleaned, and imported to IBM SPSS Statistics for Windows, Version 25.0. Descriptive statistics including means, frequencies, percentages, and standard deviations were used to report general trends in the measured variables. The Chi-square test established the significant relationships between food safety awareness and various aspects of food hygiene. Data was analysed at a level of $p < 0.05$ and presented using tables, bar graphs, and pie charts.

RESULTS

Socio-demographic Characteristics

Data collection in this study yielded responses from 128 participants, resulting in to a response rate of 82.05%. This rate surpassed the recommended threshold of 70%, which is considered acceptable as a good representation of the study population, according to Mugenda and Mugenda (2003). *Table 1* presents the socio-demographic characteristics of the respondents.

Among the total respondents, an overwhelming majority (98%) reported consuming termites, with consistent representation across all genders and age groups. The number of male respondents was almost equal to female respondents, indicating that termites are enjoyed as a delicacy by both genders. In terms of age, over half of the population (56.2%) were below the age of 35, while married individuals formed the most predominant group. Moreover, there were statistically significant differences observed between male and female respondents in the study. In terms of marital status, the most prevalent group was married individuals, accounting for 72% of the respondents. The age group of youths between 18 to 35 years represented 56.2% of the participants, while 45.3% of the respondents had attained secondary education. Additionally, the results indicate that a substantial portion of the population, 75.8%, were self-employed, engaging in activities like farming and entrepreneurship. Consumption patterns of EWT refer to the habits, behaviours, and choices that individuals or groups make regarding the consumption of EWT. These patterns can encompass various aspects, including frequency of consumption, motivation for consumption, and termite availability. Here are some key elements that shape the consumption patterns of EWT.

Table 2: Socio-demographic Characteristics

| Variable | Consumers | | Vendors | | Total | | |
|-----------------|-----------------|-----|---------|----|-------|-----|------|
| | N | % | N | % | N | % | |
| Gender | Female | 44 | 34.7 | 18 | 13.7 | 62 | 48.4 |
| | Male | 56 | 43.5 | 10 | 8.1 | 66 | 51.6 |
| | Total | 100 | 78.2 | 28 | 21.8 | 128 | 100. |
| Age | 18-25 | 50 | 39.1 | 12 | 9.3 | 60 | 48.4 |
| | 26-35 | 8 | 6.3 | 2 | 1.5 | 14 | 7.8 |
| | 35-45 | 20 | 15.3 | 5 | 4.2 | 25 | 19.5 |
| | Above 45 | 22 | 16.9 | 9 | 7.4 | 34 | 24.3 |
| | Total | 100 | 78.2 | 28 | 21.8 | 128 | 100 |
| Marital Status | Single | 22 | 16.9 | 6 | 4.8 | 28 | 21.9 |
| | Divorced | 2 | 1.6 | 0 | 1.6 | 2 | 1.6 |
| | Married | 74 | 58.1 | 18 | 13.7 | 92 | 71.8 |
| | Widowed | 2 | 1.6 | 4 | 3.2 | 6 | 4.7 |
| | Total | 100 | 78.2 | 28 | 21.8 | 128 | 100 |
| Education level | None | 1 | 0.8 | 4 | 3.2 | 5 | 3.9 |
| | Primary | 32 | 25.0 | 15 | 11.3 | 47 | 36.7 |
| | Secondary | 49 | 37.9 | 9 | 7.3 | 58 | 45.3 |
| | Tertiary | 9 | 7.3 | 0 | 0.0 | 9 | 7.0 |
| | University | 9 | 7.3 | 0 | 0.0 | 9 | 7.0 |
| | Total | 100 | 78.2 | 28 | 21.8 | 128 | 100 |
| Occupation | Farming | 48 | 37.1 | 17 | 12.9 | 65 | 50.8 |
| | Business person | 25 | 19.3 | 7 | 5.6 | 32 | 25.0 |
| | Employed | 6 | 4.8 | 0 | 0.0 | 6 | 4.7 |
| | Unemployed | 8 | 6.5 | 3 | 2.4 | 11 | 8.6 |
| | Other | 13 | 10.5 | 1 | 0.8 | 14 | 10.9 |
| | Total | 100 | 78.2 | 28 | 21.8 | 128 | 100 |

Consumption Patterns of Edible Winged Termites

Consumption patterns of EWT refer to the habits, behaviours, and choices that individuals or groups make regarding the consumption of EWT. These patterns can encompass various aspects, including frequency of consumption, motivation for consumption, and termite availability. Here are some key elements that shapes consumption patterns of EWT.

Termite consumption in Kakamega County

This study revealed in *Table 3* that 92% of the consumers have been consuming edible winged

termites since childhood while 39% and 26% were consuming edible winged termites on a weekly and daily basis respectively when they are in season. This study also identified that 57% of the respondents sourced EWT from vendors. Edible insects are known to be nutritious and, a reservoir for societal culture and heritage passed down to generations (Raheem *et al.*, 2019). The western region communities in Kenya are consumers of edible insects, termites being among the favourites (Pambo *et al.*, 2016). Most males 69% and 82% with primary education enjoyed EWT while it was raw.

Table 3: State of consumption by gender

| State of consumption | Female | | Male | | Total (%) |
|----------------------|--------|-----|------|-----|-----------|
| | N | (%) | N | (%) | |
| Processed | 59 | 96 | 55 | 83 | 89 |
| Raw | 36 | 59 | 45 | 69 | 64 |
| Semi processed | 20 | 33 | 25 | 38 | 36 |

Availability of Termites

Study results in *Table 3*, showed that 34.7% of the participants felt that the availability of termites in Kakamega County was average, 29.8% thought it

was poor. Studies agree with this trend that there has been a decline in termite availability over the years, forcing collectors to walk distance to harvest termites (Yen 2018, Kenis *et al.* 2014)

Table 4: Availability of termites in Kakamega County

| Likert Scale | Frequency | Percentage (%) |
|--------------|-----------|----------------|
| Average | 45 | 34.7 |
| Poor | 38 | 29.8 |
| Good | 32 | 25.0 |
| Very Good | 8 | 6.5 |
| Very Poor | 5 | 4.0 |
| Total | 128 | 100 |

Food Safety Awareness Among Vendors and Consumers of EWT

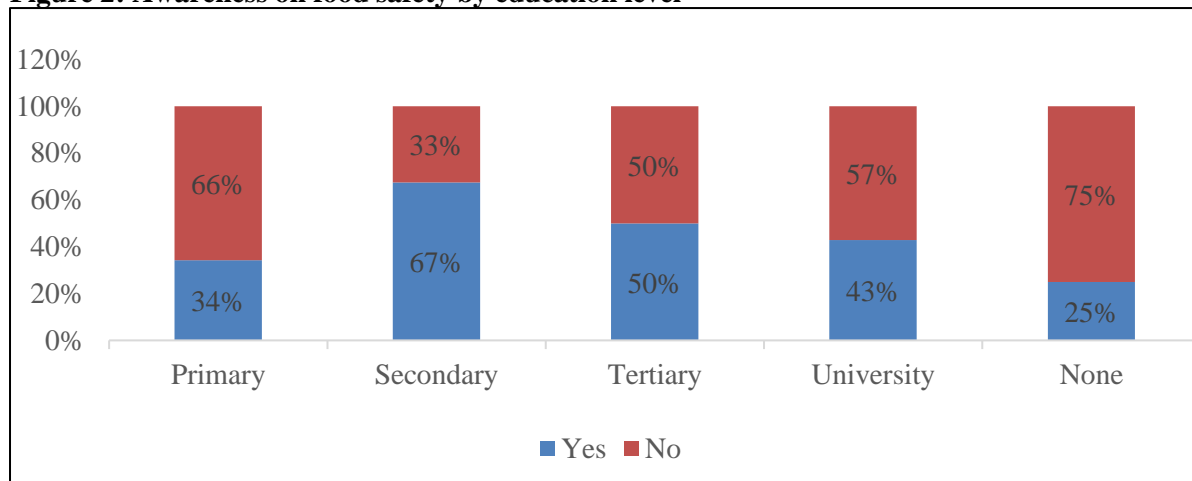
Food safety awareness among EWT vendors and consumers refers to the knowledge, understanding, and practices related to ensuring the safety of food throughout the food chain. It involves access to information, implementing proper hygiene measures, and taking steps to prevent foodborne illnesses. Here are some key

aspects of food safety awareness among EWT vendors and consumers:

Information Access

Our results showed that 43.5% of EWT consumers and vendors are aware of the term food safety (*Figure 2*). Respondents with no basic (75%) and primary education (66%) were unaware of the term food safety. The results showed that education levels influenced knowledge of food hygiene and safety.

Figure 2: Awareness on food safety by education level



Sorting, Preparation and Storage of EWT.

Study showed that 64% of EWT consumers and vendors did not practice washing termites before preparation. This poses a food safety hazard due to exposure to food contaminants. These results are comparable to Muyanja *et al.* (2011) who recorded that washing and removal of termites'

wings and legs are very essential because it reduces pathogen presence. Our results also showed that failure to wash EWT before preparation led to common health complications and symptoms including stomach pain (38%) and diarrhoea (31%) as indicated in *Table 4*. The failure to wash termites is a health risk that can make termites unsafe to eat.

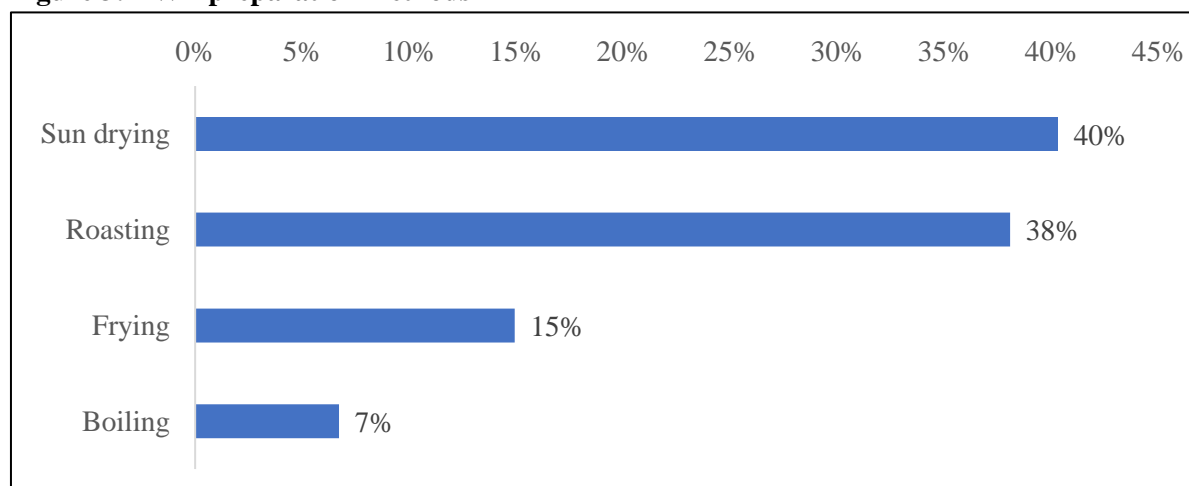
Table 5: Impact of termite washing before preparation

| Health complication after EWT consumption | Washing of EWT before preparation | | | |
|---|-----------------------------------|----|-----|----|
| | Yes | | No | |
| | n | % | n | % |
| Diarrhoea | 40 | 31 | 88 | 69 |
| Stomach pain | 48 | 38 | 80 | 63 |
| Fever | 16 | 13 | 112 | 88 |
| Nausea | 32 | 25 | 96 | 75 |

The most common preparation method was sun drying (40%), followed closely by frying (38%). Reports indicate sun-drying can enhance edible insects' nutritional quality and minimize or

prevent microbial contamination or toxins (Niassy *et al.*, 2016). The downside is that this process creates an avenue for re-contamination due to open air or soil contact.

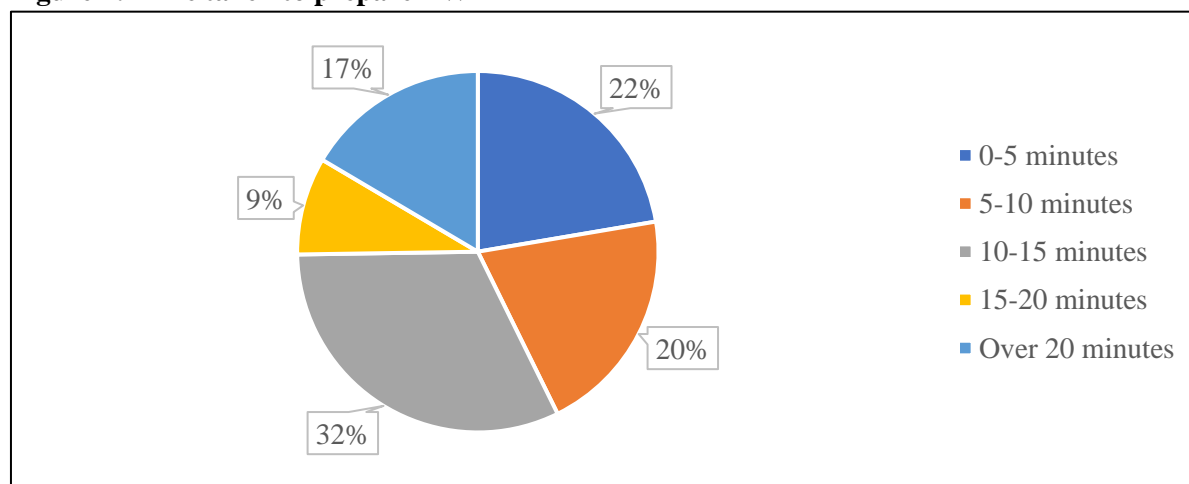
Figure 3: EWT preparation methods



It was revealed that 32% of consumers took between 10 to 15 minutes during preparation

while 9% took between 15-20 minutes as shown in *Figure 4*.

Figure 4: Time taken to prepare EWT



A Pearson Chi-square test was conducted to check the association between the EWT preparation method and the average time it takes to prepare. The p-value obtained was less than 0.05 hence we

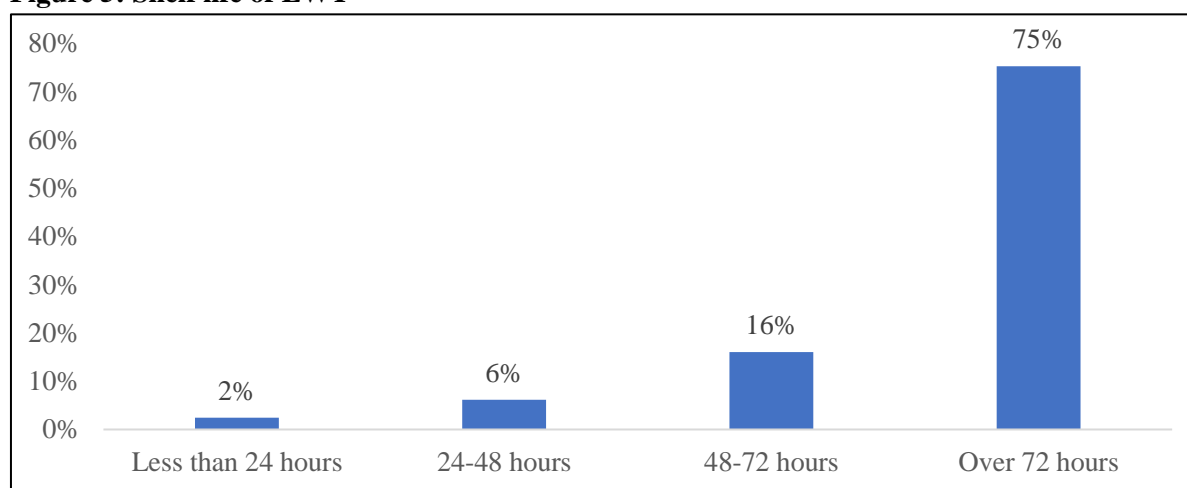
reject the null hypothesis. Therefore, there is a significant dependence between the preparation method and the average time it takes to prepare EWT.

Table 6: Association between the EWT method of preparation and time taken to prepare.

| Preparation method | Duration of Preparation | | | | | Chi-square (df) | Sig. |
|--------------------|-------------------------|--------------|---------------|---------------|-----------------|-----------------|-------|
| | 0-5 minutes | 5-10 minutes | 10-15 minutes | 15-20 minutes | Over 20 minutes | | |
| Frequency (n) | 17 | 19 | 30 | 8 | 14 | 22.747 (4) | 0.121 |
| Sun drying | 50% | 30% | 35% | 40% | 52% | | |
| Roasting | 38% | 44% | 35% | 50% | 30% | | |
| Frying | 0.0% | 22% | 23% | 0.0% | 13% | | |
| Boiling | 12% | 4% | 6% | 10% | 4% | | |

Study results indicated that 75% of the participant reported that shelf life of EWT was over 72 hours if properly maintained.

Figure 5: Shelf life of EWT



The most popular storage method was open-air container at 66%. A Fisher’s exact test was used to determine if there was a significant association

between EWT storage and their shelf life. Since the p-value <0.05, therefore there is a dependence between termite storage and termite shelf life.

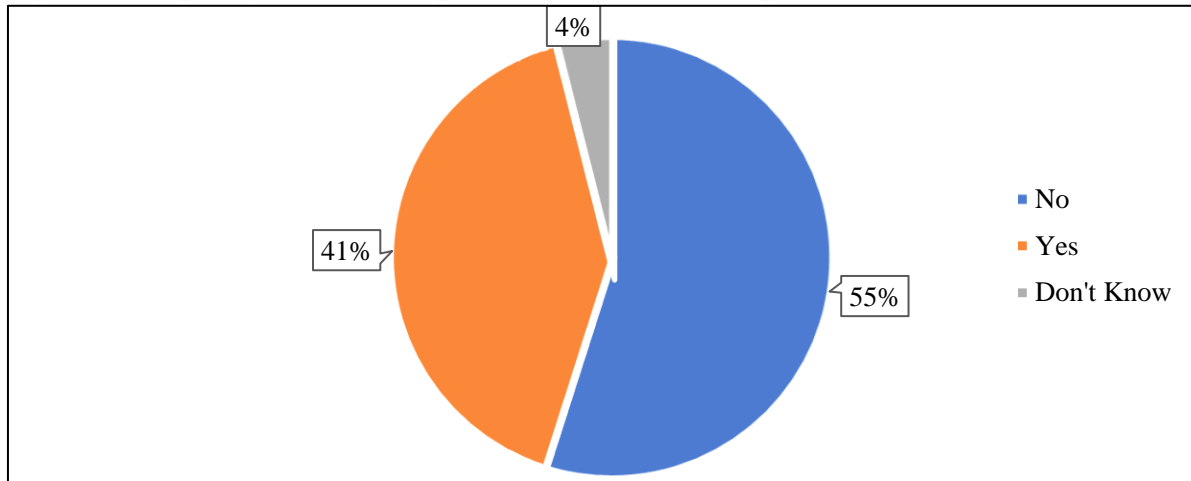
Table 7: Relationship between EWT storage and shelf life.

| Variables | EWT shelf life | <24 | 24-48 | 48-72 | >72 | Total (%) | Fisher's Exact Test | p-value |
|-------------------------|--------------------|---------|---------|---------|---------|-----------|---------------------|---------|
| | | HRS (%) | HRS (%) | HRS (%) | HRS (%) | | | |
| Storage method for EWT. | Open air container | 50 | 60 | 62 | 70 | 68 | 15.086 | 0.03 |
| | Covered containers | 0 | 20 | 38 | 21 | 23 | | |
| | Refrigerators | 50 | 20 | 0 | 0 | 2 | | |
| | Others | 0 | 0 | 0 | 8 | 6 | | |

Health Complications and Related Symptoms from Consumption of Termites

Research showed that 55% of the population did not experience any complications after the consumption of termites.

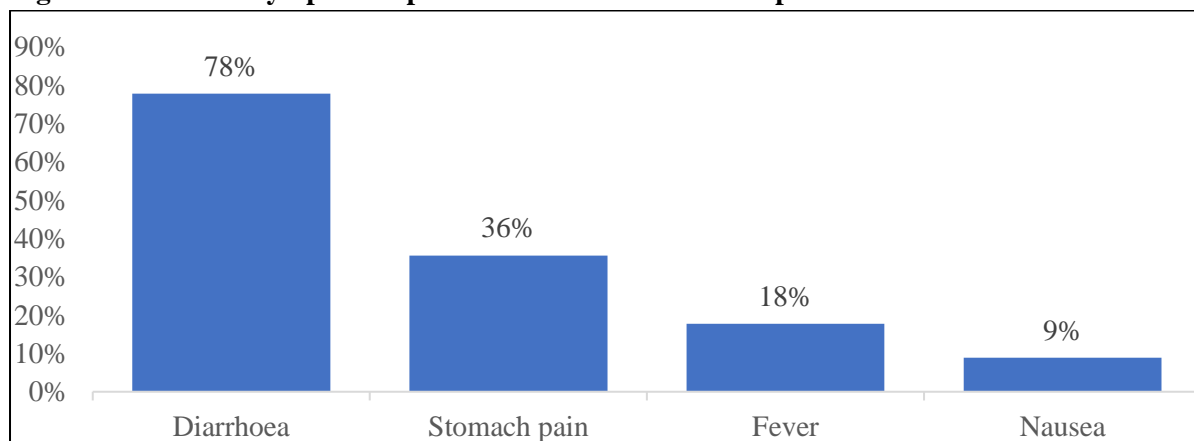
Figure 6: Frequency of health symptoms after EWT consumption



Diarrhoea at 78% was the most common symptom experienced after EWT consumption while the least experienced symptom was nausea with 9% as shown in *Figure 7*. Termites are rich in fat content (Pambo *et al.*, 2016) and could be the

reason for diarrhoea after consumption or improper handling practices and lack of hygiene along the value chain that exposed food to a myriad of health hazards that led to these health symptoms.

Figure 7: Common symptom experienced after EWT consumption



Drivers and Barriers Related to Food Safety of EWT

Drivers and barriers related to food safety of EWT encompass various factors that influence the implementation and effectiveness of food safety practices. Here are some drivers and barriers in food safety of EWT.

The findings showed that at water unavailability 46% was the main challenge experienced in achieving the food safety of EWT in Kakamega County. Poor or no excess to continuous supply of water is a major challenge and can compromise the food safety. Other barriers in achieving the food safety of EWT in Kakamega County are shown in *Table 7*.

Food Safety Challenges of EWT

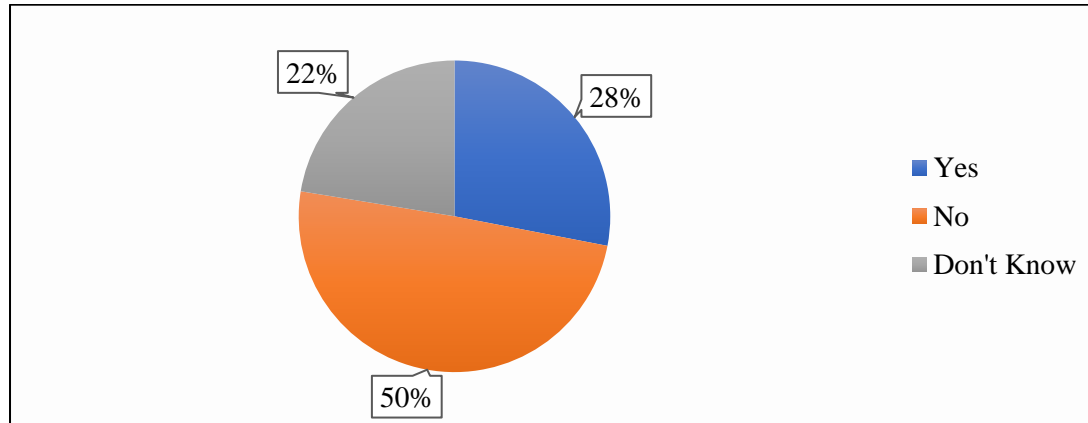
Table 8: Challenges experienced in achieving EWT food safety

| Food Safety Challenges experienced | Not Challenging | | Average | | Challenging | |
|------------------------------------|-----------------|----|---------|----|-------------|----|
| | n | % | n | % | n | % |
| Cost | 26 | 20 | 55 | 43 | 47 | 37 |
| Water unavailability | 27 | 21 | 43 | 34 | 59 | 46 |
| Lack of awareness | 51 | 40 | 50 | 39 | 27 | 21 |

Similarly, the findings indicated that 61% EWT vendors have never been inspected by food safety authorities and, 50% of the participants have never witnessed any food safety training. In

another study Mwove *et al.* (2020), reported that nearly 50% of the vendor had been uninspected by public health officials.

Figure 8: Training on EWT Food Safety



Furthermore 64% of the respondents showed that there was no toilet access or were unaware of toilet facilities in markets. This could compromise EWT vendors' hygiene and sanitation, especially when handling food. The most popular suggested intervention towards achieving food safety for termites was public awareness.

Current Food Safety Practices among EWT Vendors

This study observed personal hygiene, food handling practices, and the vending environment against a checklist. In *Table 8* EWT vendors surveyed had improper food handling practices and hygiene that can lead to contamination or foodborne illness. Hand washing was practiced by 14% and, only 4% used soap and running water while cleaning. This creates an avenue for the introduction of food hazards. The results showed that 25% of EWT vendors used proper wear and covered their hair while handling food. The use of appropriate wear and hair covering is a critical requirement for food handlers to ensure food hygiene and sanitation per the requirements of WHO, 1996. Concerning preparation, only 21% prepared EWT in small batches to limit time the

food was in the temperature danger zone. Our findings also revealed that only 12% of EWT vendors had procedures to prevent cross-contamination. The results showed that 88% of EWT vendors stored food closer to substances that could cause cross-contamination. Negligence of EWT vendors to avoid cross-contamination exposes EWT to harm. It was also revealed that only 42% EWT vendors washed food utensils or equipment after every use, similar to a study by Muyanja *et al.*, (2011). During packaging, 85% of EWT vendors used their hands to package especially raw termites. (Mwove *et al.*, 2020, Eliku 2016) also observed that 96.8% and 100% of vendors served without washing their hands. Hands can be a pathway to pathogen introduction resulting in spoilage (Ferron *et al.*, 2000). It was further observed that only 11% used proper packaging materials as most vendors used old newspapers and polythene bags. The use of improper packaging like newspapers has been established to introduce toxic materials into food (Geueke *et al.*, 2018). Packaging materials are very essential in observing food safety because they come into contact with food.

Table 9: Observation on EWT vendors' personal hygiene, food handling practices and the vending environment

| | Variables | n | % |
|---|---|--|----|
| Personal Hygiene | Vendors wear clean and proper wear | 2 | 7 |
| | Proper covering of hair | 2 | 7 |
| | Clean, short, and unpolished fingernails | 26 | 92 |
| | Not wearing jewellery when handling cooked food | 15 | 54 |
| | Proper handwashing frequently, and at appropriate times | 4 | 14 |
| | Properly dressed burns, wounds, or cuts with bandages | 14 | 50 |
| | Prohibition on drinking, chewing gum, smoking, or using tobacco at vending premises. | 14 | 50 |
| | Mouth covering by vendors when coughing or sneezing and immediate hand washing. | 3 | 11 |
| | Vendors appear in good health | 27 | 96 |
| | Proper hand washing with soap and running water after handling money or visiting the toilet | 1 | 4 |
| | Vendors use operational and clean toilets | 4 | 14 |
| | Termite Preparation | Preparation of small food batches to limit the time in the temperature danger zone | 6 |
| Termites are stored or prepared in clean and safe environment | | 5 | 18 |
| Use of hands directly to serve food to be eaten immediately | | 24 | |
| Food equipment, utensils, and food contact surfaces are properly washed and rinsed before every use | | 12 | 42 |
| Procedures are in place to prevent cross-contamination | | 3 | 12 |
| Termite Storage | Foods storage away from any chemicals or contaminants | 5 | 18 |
| | Food is protected from contamination | 4 | 14 |
| | Food is stored in containers with tight fitting lids | 14 | 50 |
| | The use of FIFO (First In, First Out) method | 4 | 14 |
| | All food surfaces are kept clean | 12 | 43 |
| | All foods are stored 6 to 8 inches off the floor | 2 | 8 |
| | Food is stored in original container or a food grade container | 2 | 8 |
| | Safe materials for food packaging | 3 | 11 |
| | Regular cleaning schedule for all food surfaces | 4 | 14 |
| Maintenance of dry storage temperatures (50 °F and 70 °F) | 1 | 4 | |
| Garbage | Garbage cans are clean and kept covered | 17 | 62 |
| | Garbage cans have tight fitting lids | 4 | 14 |
| | Garbage cans are emptied as necessary | 6 | 21 |

DISCUSSIONS

The study contacted 128 selected participants from the three sub-counties in Kakamega: Likuyani, Khwisero, and Lurambi. Results reported that 98% consume termites distributed across all genders and age groups. This closely aligns with the findings of Nyeko and Olubayo (2005) in Uganda, who reported a consumption rate of 94.23%. The number of male respondents was almost equal to female respondents, indicating that termites are enjoyed as a delicacy by both genders. In terms of age, over half of the population (56.2%) were below 35, while married

individuals formed the most predominant group. Studies suggest youths are more likely to participate in upcoming studies due to their curiosity and desire for new experiences. A significant percentage of vendors had only attained secondary education, completing secondary school education enabled most participants to make informed decisions concerning entomophagy.

Their primary occupation was farming, as most residents depended on agriculture as their main source of livelihood. Consumers have been incorporating termites into their diets since birth.

A study by Kusia (2021) matches the study's findings that reported that 92.3% of children are involved in the insect value chain. While vendors supplied over 57% of termites for consumption, the uneducated group preferred to source termites themselves. Conclusions made by previously conducted research allude to the impact of foreign culture negative perception on the consumption of edible insects, especially among the educated and urban dwellers where entomophagy is viewed as a primitive practice (Verbeke, 2015). Traditional beliefs played a significant role in why respondents consumed termites, a finding that corresponds with results carried out by Florença *et al.*, 2022 indicating tradition/culture as a motivation. Seasonal changes and poor agricultural practices were the leading causes of termite unavailability in Kakamega County.

Food safety knowledge was found to be slightly above average. Termite hygiene was reported as the most influential factor guiding consumers' purchase decisions. A minority of participants practised termite washing before preparation, even though washing termites is essential in ensuring food quality and safety and should be adhered to. In line with the results of the current study, Mwove *et al.*, 2020 recorded that 86.1 vendors had unwashed hands. Results also showed that the failure to wash termites contributed to health symptoms such as nausea and fever, with diarrhoea being the most common. From the Pearson Chi-square test conducted, it was observed that there was an association between the preparation method and the time taken for preparation, revealing a significant dependence between the two variables. A Chi-square test revealed a significant relationship between consumption and health complications. This can be attributed to either the collection site or the high-fat content in termites, as indicated by Imathiu, 2020.

Observation of the vendors' hygiene, food handling practices, and the vending environment revealed an overall negative result. Furthermore, most vendors had their hair covered appropriately, in contrast to several studies by Cortese *et al.*,

2016, Eliku, 2016 and Muhonja, 2014. Vendors did little to maintain preparation and storage surface hygiene or prevent cross-contamination. Many vendors neglected to wash utensils or surfaces after each use. Using hands to serve termites was another observed practice similar to the study by Mwove *et al.*, 2020. Inappropriate packaging materials compromise food safety. However, there were positive results, as most vendors did not wear jewellery which coincide with results findings by Chukuezi, 2010 and Muinde *et al.*, 2005. Majority of the vendors had clean, short fingernails that promoted food hygiene. Termites were prepared in large quantities and stored at ambient temperature, making them susceptible to food contamination.

Water unavailability was the main challenge hindering the food safety of termites, as most households relied on boreholes and river water supply. According to Nanyunja, 2016 lack of inspection for vendors, raised concerns about food safety and integrity that affect consumers' health. Nearly all markets lacked toilet access, posing risks to hygiene and sanitation, especially during food handling.

CONCLUSIONS

This study provides valuable insights into the socio-demographic characteristics, food safety awareness, practices, and challenges related to the consumption and vending of edible winged termites in Kakamega County. The findings reveal that termites are widely consumed by both males and females across different age groups, with married individuals forming the majority of consumers. Most consumers have been incorporating termites into their diets from a young age, and traditional beliefs significantly shape their consumption habits. While the food safety knowledge among vendors and consumers is slightly above average, there are areas of concern. Termite hygiene emerges as a critical factor influencing consumers' purchase decisions, but a minority of respondents practice termite washing before preparation, sometimes leading to health symptoms. Additionally, vendors' hygiene and food handling practices were found to be

subpar, with inadequate handwashing and inappropriate wear being common issues.

The study highlights the challenges hindering termite food safety, notably water unavailability and the lack of food inspection on termite vendors. These challenges and a lack of food safety training among vendors create risks for consumers' health and the quality of the termites sold in the markets. To address these issues and promote food safety, raising awareness among vendors and consumers about proper termite hygiene and handling practices is essential. Additionally, implementing regular food inspections and providing food safety training for vendors can significantly improve the safety and quality of termites sold and consumed in Kakamega County. This study emphasizes the need for proactive measures and policies to ensure the safe consumption of edible winged termites, considering their cultural significance and economic potential in the region. By addressing the identified challenges and promoting food safety awareness, Kakamega County can unlock the full benefits of incorporating termites into the local diet while safeguarding public health and well-being.

Recommendations

Termites play a crucial role in the diets of these communities, offering potential solutions to malnutrition, food security, and livelihoods. To maximize their benefits, ensuring food safety, nutritional quality, and consumer confidence is essential. Educating all stakeholders, including vendors, collectors, consumers, and governments, on food safety and hygiene practices is recommended. Training programs have proven effective in promoting better hygiene practices and safer food. Vendors should receive proper training in sanitation, food handling, and access to potable water. Strengthening the government's enforcement of food safety policies and consumer sensitization is vital to safeguard public health interests. Prioritizing consumer education on food safety will empower informed decision-making. This study's insights contribute to improving food safety and hygiene knowledge, informing future

food policies and laws, and fostering food safety awareness and training programs.

ACKNOWLEDGEMENT

The authors would like to extend their deepest gratitude to Jaramogi Oginga Odinga University of Science and Technology through the African Centre of Excellence for the sustainable use of insects as food and feed (ACE-INSEFOODS) in collaboration with the World Bank. A special thank you to the consumers and vendors who participated in the research and made it a success.

Conflict of interest

The authors declare that there are no conflicts of interest.

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