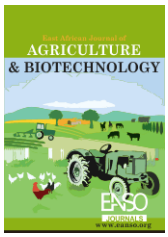

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Original Article

Value Chain Mapping of Edible Termites (*Macrotermes subhylanus*) as an Alternative Source of Income to Rural Livelihoods in Alego Usonga

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Alate Termites, Value Chain, Mapping, Income, Rural Livelihoods.

ABSTRACT

Reducing food insecurity remains a public policy challenge in developing countries. Food insecurity becomes severe in areas where households highly depend on undiversified livelihoods. Entomophagy has been perceived as a solution towards food security due to its nutritional benefits, environmentally friendly attributes and its potential to generate income. However, information to aid its commercialisation is limited, hence the need for value chain mapping. This paper assesses the value chain of edible termites (Macrotermes subhylanus) in Alego Usonga Sub County with the aim of promoting it as an alternative source of income. This study sought to understand the value chain actors from input supplier to consumption and their role in the value chain. Simple random sampling was used to obtain participants for the study. Face-to-face interviews and structured questionnaires were administered to 225 respondents to collect data on value chain actors and their roles. Value chain mapping technique was used for functional and technical analysis of the alate termites' value chain. The data was analysed using descriptive statistics Chi-square tests, with the aid of Statistical Package for the Social Science (SPSS) version 20. Value chain actors in the termite value chain included input suppliers (1.8), producers/collectors (4%), retailers (13.3%) and consumers (80.9). There was a significant difference ($P \leq 0.05$) in terms of input supplier and producer/ collectors of termites; a high significant difference ($P \leq 0.001$) was also recorded in hawkers and retailers, where women were reported to play a vital role in hawking and retailing of termites. In terms of transportation, human transport (82.7%) was preferred over motorbikes. Although the value chain actors agreed that edible termites could contribute to additional sources of income, the sector was insufficiently supported by farmer groups and associations, lending institutions, research, and extension service providers.

APA CITATION

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INTRODUCTION

Kenya is the fourth largest economy in Sub-Saharan Africa. The agricultural sector is the backbone of Kenya's economic growth, meaning overall development is dependent on agricultural improvement. However, due to COVID-19, the food system seems to be threatened; access to food became difficult through losses of income and assets, thereby making it impossible to access or buy food and consumers demanding cheaper, less nutritious foods (Nechifor, Ramos, Ferrari, Laichena & Kihiu, 2021). More has been done on edible insect rearing, processing, nutrition and health, and consumer behaviour (e.g. Kinyuru & Ndung'u, (2020) on promoting edible insects in Kenya; Alemu et al. (2015) on consumer acceptance and willingness to pay for edible insects as food in Kenya). However, future chain efficiency would benefit from further multi- and interdisciplinary knowledge gain and other important factors like business development, enabling regulation, increased marketing and promotion, and fostering industrial partnership. These activities require collaboration among the actors within the insect chain (Lakemond et al., 2019).

Entomophagy is a traditional practice in Kenya; according to Kusia et al. (2021), some of the insects consumed in Kenya include termites (88%), grasshoppers (28%), saturniids (8.3%), crickets (6.8%), compost grubs (3%) and lake flies (1.5%). There are four species of edible winged termites (*Macrotermes subhylanus*, *Macrotermes bellicosus*, *Pseudocathotermes militaris* and *Pseudocathotermes spinger)* which are consumed in western Kenya (Kinyuru et al., 2013). Among these, *Macrotermes subhylanus* and *Macrotermes bellicosus* were identified to be the most common and the most delicious. Therefore, *Macrotermes subhylanus* was chosen for the study since it is common and is considered delicious, which means it has a high demand when offered on the market or made available.

Edible insects are perceived to have the potential to address food insecurity challenges; according to Mahajan, Kumar and Agarwal (2022), edible insects offer nutritional benefits, which include protein, lipids, carbs, dietary fibre, some vitamins, and minerals. Kinyuru et al. (2015) further acknowledge that large-scale production and use of edible insects can help to improve the environment, health, and livelihood of those consuming them. This is supported by a study by Mahajan et al. (2022), which found that cereals fortified with termites and caterpillars would enhance children's iron status. This is important since every nation's goal is to achieve food security for its people while conserving the environment. Therefore, this study focuses on the consumption of edible insects as a livelihood diversification opportunity in the study area.

Entomophagy and trade are deemed as a solution to food security since insects are rich in protein and other nutrients and could act as an alternative livelihood diversification opportunity, especially in areas where the land for crop production is limited, and this could help in poverty reduction through the additional incomes derived from insect trade whereby the income could be used to meet other dietary demands. However, important information to support its commercialisation is

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scant(CAROLINE, 2018), hence the need for value chain mapping.

METHODOLOGY

Study Area

The study was carried out in Siaya County, Alego-Usonga Sub County. The County is bordered by Busia County to the north, Kakamega and Vihiga Counties to the northeast, and Kisumu County to the southeast. The total area of the county is approximately 2496.1 square kilometres. The county lies between latitude 0˚ 26˚ to 0˚ 18˚ north and longitude 33˚ 58˚ east and 34˚ 33˚west (Siaya County Development Office, 2018). The area is chosen for its endowment with plenty of insects and, in our case, the alate termites commonly known as the "Agoro termites.

Figure 1: Map for Siaya County

Source: Adopted from Kinyuru (2009)

Research Design

A survey design was used for this study; structured questionnaires and face-to-face interviews were conducted across the wards to obtain information on value chain actors and their roles.

Sampling Technique

To ensure the inclusion of individuals who are knowledgeable and experienced in termite farming or collection and marketing, a simple random sampling criterion was used. First, Respondents from each study area were randomly selected. This involved selecting an initial respondent randomly at each ward, conducting face-to-face interviews with the identified respondent, then asking the respondent to identify other termite value chain actors, and then the next respondent was chosen randomly from the identified households. The process was repeated until the desired sample size of 225 households was attained.

For other value chain actors (input suppliers, output traders, marketers and processors), the samples were drawn from those identified along the value chain and followed up by interviews as key informants. Structured questionnaires were also administered.

Sample Size Determination

The study used the formula by Nassiuma (2000) to determine the sample size:

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

Where: n = the calculated sample size; N = the population (250,698); C = the coefficient of variation (21% ≤e ≤30% acceptable); e = the standard error (2% ≤e ≤5% acceptable); Now, taking N = 250,698, C = 30% and e = 2%, we obtain the sample size as follows:

$$n = \frac{NC^2}{C^2+(N-1)e^2} = \frac{250{,}698*0.3^2}{0.3^2+(250{,}698-1)*0.02^2} = 224.78 = 225$$

Where n = Sample size, N = population (250,698), C = Coefficient of variation (30%), and e = Standard error (2%). Nassiuma (2000) asserts that in most surveys, a coefficient of variation of between 21% ≤C ≤30% and a standard error in the range of 2% ≤e ≤5% is usually acceptable. A high coefficient of variation was used in the study to ensure that the sample size was wide enough to justify the results being generated from the study area. To minimise the degree of error, a lower limit for standard error was used. As a result, 225 household respondents were sampled for the purpose of the study.

Data Collection

An exploratory survey design was used for a better understanding of the termite value chain. In addition, a mixed-methods design was employed, using both quantitative and qualitative techniques**.** The purpose of the mixed method design was to obtain a more comprehensive view and more data on termite value chain activities and the roles of value chain actors, which could not be captured entirely by closed-ended questions in quantitative data, as well as to obtain details of the chain actors' personal experiences, as recommended by Creswell (2014).

Data was collected using structured questionnaires and face-to-face interviews. Questionnaires consisting of a list of questions were administered to the respondents to obtain information on all the actors in the value chain of the alate termites. Open-ended questionnaires were used to allow the respondents to list potential households involved in insect collection and trade; this included the socioeconomic profile of the respondent: gender, age structure, highest educational level, family size, and occupation, operation: participation and roles played in the chain (production, processing, and marketing), access to support services, and organisations involved, forms in which termites are sold, seasonality, packaging and volume sold, consumption by different groups, prices, and price determination, market distribution channel, infrastructure (rural and urban markets), storage facilities and information access.

Data Analysis

The SPSS software was used to analyse the data. Value chain mapping technique was used for functional and technical analysis of the alate termites' value chain. A horizontal value chain map was used to depict upstream activities and functions such as termite harvesting or collection and downstream activities such as wholesaling and retailing of termites.

Qualitative data on value chain actors and their respective roles was recorded and analysed using the value chain analysis approach. Flow diagrams and tables were used to present the analysed data. Descriptive and inferential statistics, such as percentages, frequencies and the chi-square tests, are used to describe sociodemographic characteristics and the roles of value chain actors.

RESULTS AND DISCUSSIONS

Sociodemographic Characteristics of the Participants

A total of 225 respondents answered the questionnaire, and their socioeconomic characteristics are shown in *Table 1*. It was noted that female respondents (72%) were across the wards; East Alego had more males compared to other wards. 52.4% were aged between 36 -60 years, West Alego leading, 40.9% were aged above 60 years. Township had the highest, with only 6.7% aged below 36 years. 41.8% of the total population were unemployed, west Alego and Township leading with 56.0% being self-employed across the wards, with 88% earning a

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monthly income of less than Ksh. 11,000/-. In terms of academic achievement, 85.3% of respondents across the wards only attended up to the primary level, with 12.9% attaining secondary level and only 1.8% from East Alego attained postsecondary level.

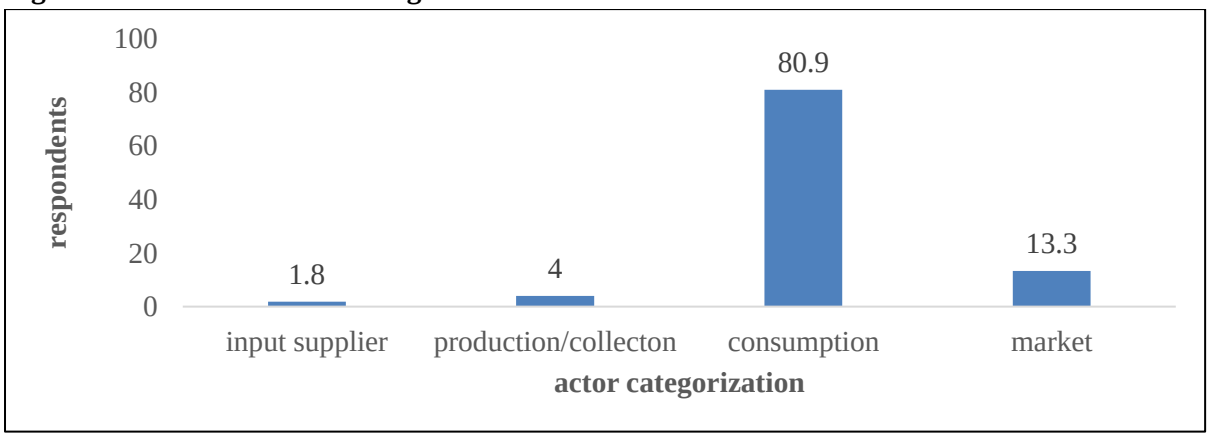
Table 1: Proportional distribution of socioeconomic variables of termite value chain actors across the wards.

Variable		WARD					df	Chi-square	P-value
		East Alego	West Alego	Township	Total	(%)			
Gender	Male	26	18	19	63	28	2	2.513	0.285
	Female	49	57	56	162	72			
Age	<36 yrs.	8	4	3	15	6.7	4	3.405	0.493
	36 - 60 yrs.	37	42	39	118	52.4			
	>60 yrs	30	29	33	92	40.9			
Marital status	Married	51	55	58	164	72.9	4	9.419	0.051
	Widowed	18	19	17	54	24			
	Single	6	1	0	7	3.1			
Occupation	Self-employed	45	40	41	126	56	4	6.895	0.142
	Employed	4	1	0	5	2.2			
	Unemployed	26	34	34	94	41.8			
Income	<11,000	58	70	70	198	88	2	12.12	0.002
	11.000 - 20,000	17	5	5	27	12			
Family size	< 6 persons	50	56	50	156	69.3	2	1.505	0.471
	5 - 10	25	29	25	79	30.7			
Education	Primary	55	70	67	192	85.3	4	16.66	0.002
	Secondary	16	5	8	29	12.9			
	Postsecondary	4	0	0	4	1.8			

Termites' Value Chain

The data obtained from the structured questionnaire was used to identify actors in the value chain, as shown in *Figure 2.*

Figure 2: Value chain actor categorisation across the ward



The study identified key value chain actors in the termites' value chain (*Figure 2*), which included input suppliers (source of light, (1.8%), producers/collectors (4.0%), processors, distributors (transporters, traders) retailers (13.3%) and consumers (80.9%).

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Table 2: Value chain actors across the wards

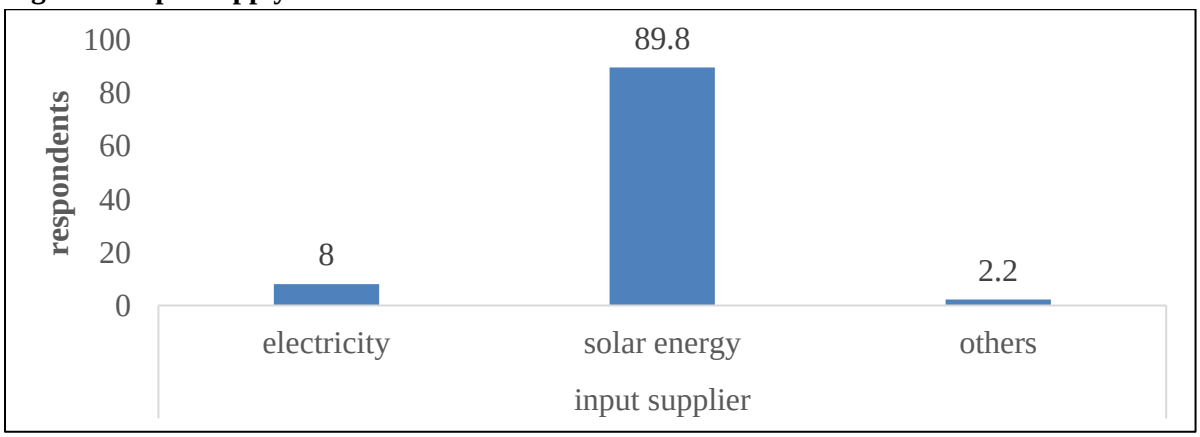
Variable		Ward (%)			Total (%)	chi-square	p-value	df
		East Alego	West Alego	Township				
Input supplier	Electricity	4.4	1.8	1.8	8.0	15.198	0.004	4
	Solar energy	26.7	31.6	31.6	89.8			
	Others	2.2	0.0	0.0	2.2			
Producer	Individual	31.1	33.3	33.3	97.8	10.227	0.006	2
	None	2.2	0.0	0.0	2.2			
Wholesalers	Absent	31.6	32	32.9	96.4	1.815	0.404	2
	Present	1.8	1.3	0.4	3.5			
Retailers	Women	27.1	33.3	33.3	93.8	29.858	0.000	4
	None	3.6	0.0	0.0	3.6			
	Male/female	2.7	0.0	0.0	2.7			
Middlemen	Absent	32.9	33.3	33.3	99.5	2.009	0.366	2
	Present	0.4	0.0	0.0	0.4			
Hawkers	Women	8	0.4	3.1	11.5	19.395	0.000	2
	None	25.3	32.9	30.2	88.4			
Transporters	Human transport	24.4	26.7	31.6	82.7	12,469	0.002	2
	Motorbikes	8.9	6.7	1.8	17.4			
Major consumers	Schools /hospitals	2.2	0.4	0.4	3.0	4.218	0.95	2
	Local consumers	31.1	32.9	32.9	96.9			
Channel of distribution	C-C	19.1	23.6	19.1	61.8	5.580	4	0.233
	C-R-C	13.8	9.8	14.2	37.8			
	C-W-C	0.4	0.0	0.0	0.4			

N*/B: c-c –collection to consumer; c-r-c – collection to retailer to consumer; c-w-c – collection to wholesaler to consumer*

Input supplier

The main input suppliers that provided a source of light for the collection of termites were solar companies, electricity and others, as shown in *Figure* 3

Figure 3: Input supply sources



There was a significant difference ($P \leq 0.05$) in the input supply in the termite value chain, where solar energy (0.004), namely Sunking, Mobisol, Pawame and Delight, provided a source of light for termite collection, followed by electricity and others such as lantern and candles. Solar energy played a crucial role by giving farmers their products on loans and allowing them to pay a given specified amount on a daily/monthly basis. This was helpful owing to the fact that having a

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source of light at home made it easier for producers/collectors to collect the termites as they were attracted to the light source and didn't have to move around at night as compared to electricity where farmers were forced to go to nearby markets where electricity is installed for them to collect termites as many of them did not have electricity in their homes due to its high costs. Out of the total number of respondents, only 4.4% of them from East Alego reported having access to both electricity and solar company products and agreed that having a good lighting system guaranteed bumper harvests. However, it should be noted that farmers encountered some constraints in terms of the inputs, which included power blackouts, daily solar charges, and high initial costs of electricity caused by poor weather and inadequate capital, which made them harvest very low amounts of termites.

Producers/Collectors

This study sought to identify producers or collectors of termites and whether they were farmed or collected from the wild.

Figure 4: Termite producers/collectors

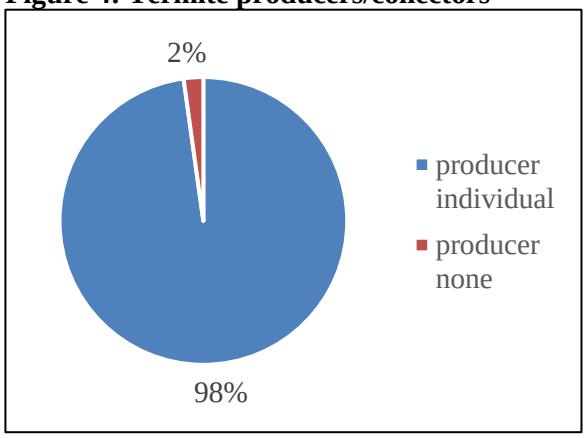
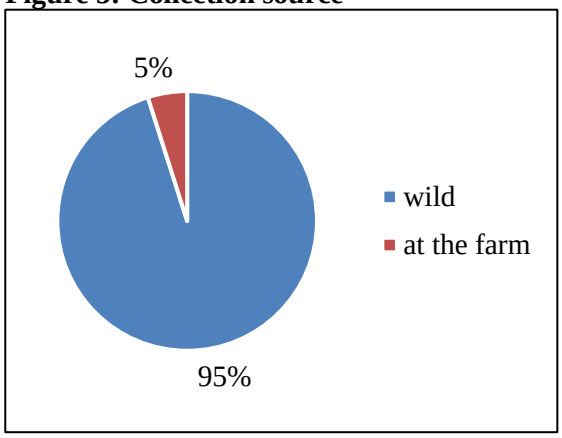


Figure 5: Collection source



There was a significant difference in production or termite collection ($P \leq 0.05$) as the majority of the respondents (98%) across the wards were involved in termite collection. It was also noted that there was no farming of termites at the farm level. Instead, farmers still collected termites from the wild (95%), and very few farmers (5%) still had termite mounds in their farms, as shown in *Figure 5*. They all still depended on nature for the supply of termites and collected individually (men /women) or as a family. Given the fact that they collected from the wild at night, they incurred problems such as attack by wild animals, mosquito bites, insecurity (theft/ stealing of the harvest), and limited/lacking knowledge on production, making it impossible for the producers/collectors to farm and therefore depend on nature for their supply and the fact that the termite industry is still an informal industry due to unrecognition by the government agencies and certification bodies, its adoption is still so low.

Processors

After collection, the collected termites were then fried by women who then sold them to rural households, local markets/trading centres and roadside markets. It's important to note that at this level, the value addition of termites was very low, and the raw termites were only fried and sold to the market in one form. There is a need for processors to be trained on other value-addition techniques in order for them to diversify their products, as this will help them to obtain better prices and more profits.

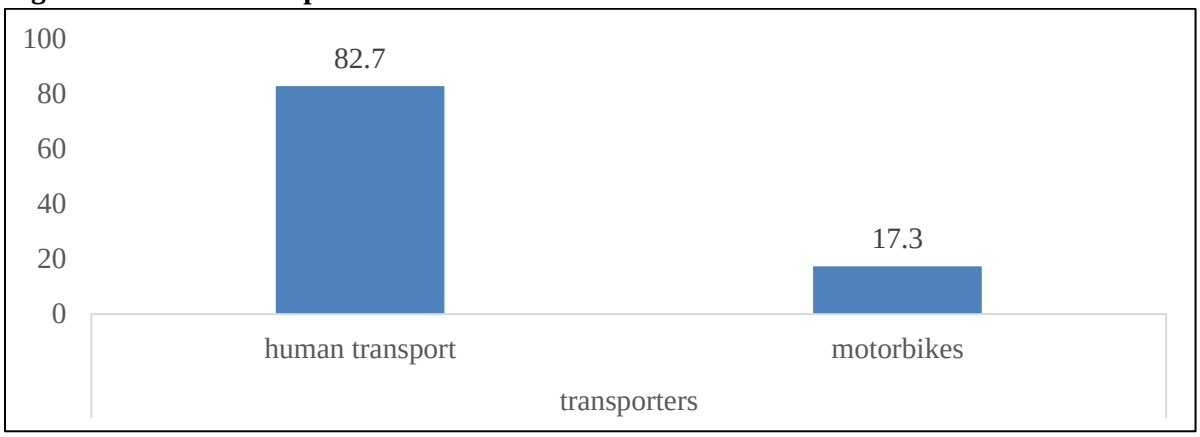
Distributors (Transporters/Traders)

It was found that in the termite industry, distributors were very limited or even absent; this could be attributed to the fact the industry is still informal and not yet recognised by government bodies or certification agencies. Very few wholesalers were reported in East Alego to have been coming from Luanda, although they were not

Article DOI : https://doi.org/10.37284/eajab.6.1.1446

known, and most individual traders sold directly to the consumer.

Figure 6: Mode of transportation of termites.

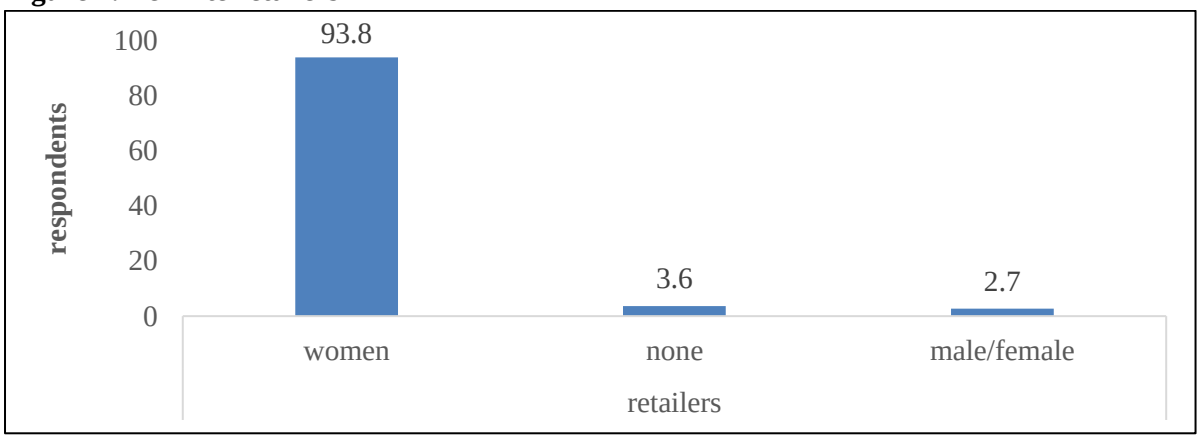


Termites were transported to the market mostly through human transport (82.7%), as shown in *Figure 6*, which means they were only sold at the nearest trading centres or markets and motorbikes were only used if the local markets were far away.

Retailers (Small and Medium Enterprise Women, Individual Farmers/Collectors)

The study reported a high significant difference ($P \leq 0.001$) among the retailers across the wards; most retailers were small and medium enterprise women who, during the on-season for the termites' incorporated termites in their stock /sales. Also, individual farmers/collectors who had excess would personally sell to the market, with 81.3% being sold in the village markets.

Figure 7: Termite retailers



Women (93.8%) played a key role in the marketing of termites, which accounted for almost 100% of the termite sellers. It is important to note that retailers accounted for 13.3 % (market actors) of the value chain actors, which, when compared with consumption, indicates that demand exceeds supply in the market. At the market, trades encountered constraints such as flooding of the market during the season, devaluation of termites where termites were seen as a gift of nature and should not be sold, or people tasting free and seasonal markets, which forced traders that had not diversified out of the market.

Consumer

The study sought to understand whether there were institutions or restaurants that consumed termites or whether consumption was only by local consumers.

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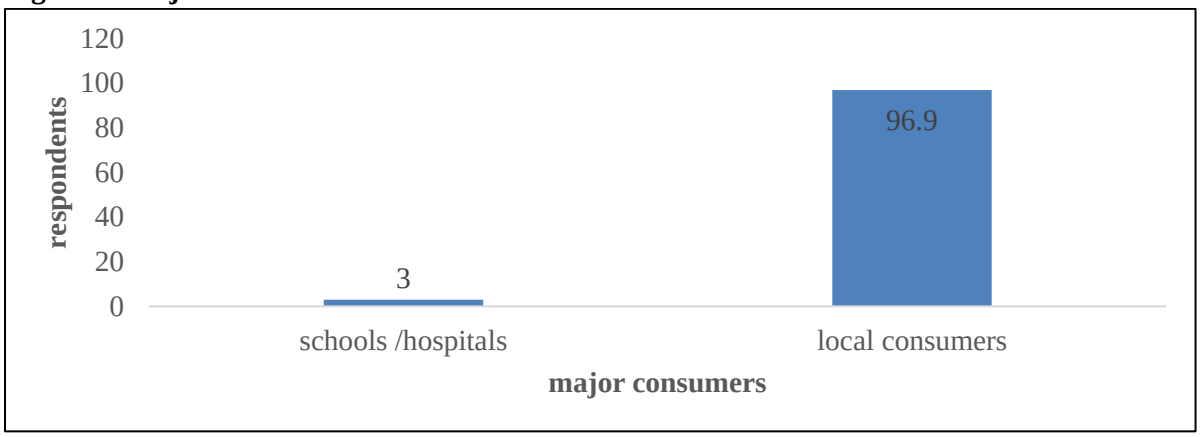
Figure 8: Major consumers



The respondents reported little or no consumption at the institution level; rather, alate termites were consumed by local consumers (96.9).

From the study, it was concluded that most consumption of termites took place during one season (90.7%), with 80.9% comprising consumers. It was also noted that termites remain a loved delicacy among them and are consumed by almost everybody in the family, with a few cases citing none consumption due to allergic reactions, irritation feeling, and excess fats with the consumption rate being high; this indicates a very readily available market for traders waiting to enter the industry. Although consumption is high, there was very little/no record of consumption in institutions or restaurants.

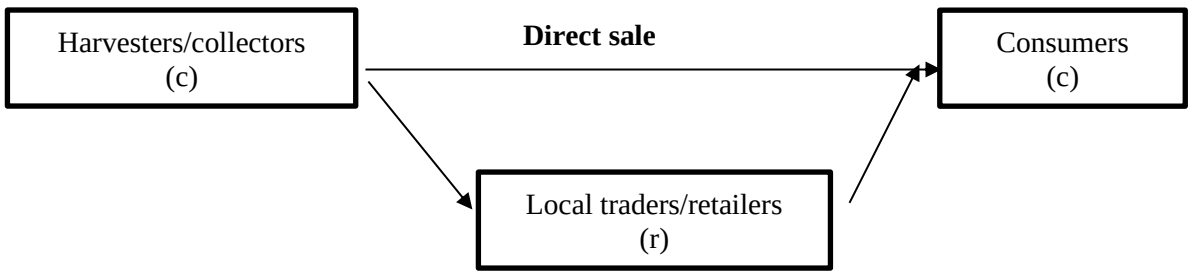
Service Providers

The termite /insect industry being an informal industry, receives no services from cross-cutting industries or extension services. The only service providers in the industry are the family labour, which aids in the production/collection of termites, and women (97.3%), who played a key role in terms of consumption by frying the termites for consumption.

Distribution Channel

The study sought to understand the movement of termites until they reached the final consumer.

Figure 9: distribution channel for termites



The main distribution channel in the termite industry was identified to be from the collectors to consumers (61.8%), which means that most farmers/collectors consumed what they harvested, and if there was excess, they shared it with their neighbours. This was followed by from collectors to retailers to consumers (37.8%), which means that collectors who had excess sold to retailers, who in turn sold to the final consumer.

Marketing Constraints

Since the aim of the study was to promote alate termites as an alternative source of income, the study further looked at the marketing constraints faced by traders of alate termites, as shown in *Table 3*.

There was a high significant difference ($P \leq 0.001$) in the marketing constraints across the

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wards, with 80.5% of respondents citing no constraint; they related this to the fact that termites were a delicacy and once they started swarming, selling them was not difficult. Others cite flooding of the market during one season, devaluation of termites where termites were seen as a gift of nature and should not be sold, and seasonal markets where traders who solely depended on termites as a source of income were forced to exit the market.

DISCUSSION

This study noted that there were more female respondents than male respondents in the study area; the majority of the respondents were between 36-60 years, married and self-employed, earning an income of < 11,000 with most of them recording a primary level of education. The high female participation conforms to a study by Ogal et al. (2022), which also recorded more women than males and attributed it to the fact that women were more responsible for feeding their families.

It's important to note that there was no farming of termites at the farm level; instead, farmers still collected their termites from the wild, which were fried for consumption and the excess sold in the nearby local markets with little value addition which, therefore agrees with a study of marketing of edible insects in lake Victoria basin (Odongo et al., 2018) that household collections were largely consumed within the homes and a small proportion was sold to neighbours and that marketing of edible insects was characterised by minimal value addition, lack of standardisation and adequate market information which is the same case with this study.

The study identified key value chain actors in the termites' value chain, which included input suppliers, producers/collectors, processors, distributors (transporters), retailers (traders) and consumers. Solar energy was a major provider of a source of light. Producers or termite collectors were more common across all the wards, and human transport was preferred over motorbikes. The study noted a disparity in gender where women were involved in the collection, preparation, hawking and retailing of the termites at the market than male actors; this corresponds to a study by Anyuor et al. (2022) that stated that women were more involved in termite harvesting and trading. Apart from the key value chain actors, the termite value chain was insufficiently supported by farmer groups and associations, lending institutions, research and extension services, and other service providers. The market segment was faced with challenges such as flooding of the market during one season, devaluation of termites, seasonality, no clear channels and policies, limited knowledge on production, attack by wild animals and mosquito bites

Although momentum has been generated, and insects are now perceived as being a potential solution to food insecurity and income and job creation among the youth, the entire edible-insect value chain has not revealed its potential (Niassy et al., 2018) and this can also be seen in the termite market which seems not to have established itself as links between the value chain actors seem to be disconnected, an example is where most producers/collectors sell the excess directly to consumers or just gift to their neighbours, intermediaries who play key role in providing important market information are either lacking or unknown an example being wholesalers/brokers who are not known by the respondent.

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Table 3: Marketing constraints across the wards

Variable		Ward (%)			Total (%)	chi-square	df	p-value
		East Alego	West Alego	Township				
Market constraint	Devaluation of termites	3.6	0.4	0.9	4.9	51.028	14	0.000
	Inappropriate packaging	1.3	0.0	0.0	1.3			
	Flooding of the market during the season	4.9	1.3	0.0	6.2			
	Lacking/ poor dissemination of market information	1.3	0.0	0.0	1.3			
	Inappropriate infrastructure/being rained on	0.4	0.0	0.0	0.4			
	Seasonal markets	0.4	0.4	3.6	4.4			
	No established markets/std prices	0.4	0.4	0.0	0.8			
	None	20.9	30.7	28.9	80.5			
Market cause	Consumers eating freely without paying	5.8	0.8	4.9	11.5	37.023	12	0.000
	Dependency on nature	1.3	0	0.0	1.3			
	Unregulated prices	0.4	0.8	0.0	1.2			
	Knowledge gap/information	0.4	0.0	0.0	0.4			
Market effect	No designated/established markets for termite	1.3	0.0	0.0	1.3	20.056	6	0.003
	Excess supply	3.1	0.8	0.0	3.9			
	None	20.9	30.7	28.4	80			
	Fluctuating prices	2.2	0.4	1.7	4.3			
	Buyers testing without paying/reduced profit	5.3	1.7	1.3	8.3			
	Market exit	3.6	0.4	1.3	5.3			
	None	22.2	30.7	28.9	81.8			
Market intervention	Value addition	2.7	0.8	0.8	4.3	30.267	12	0.003
	Value sensitisation	1.3	0.8	0.4	2.5			
	Better packaging material	1.3	0.0	0.0	1.3			
	Price regulation	1.8	0.0	0.8	2.6			
	Sharing of market information	4	0.0	2.2	6.2			
	Price regulation	1.3	0.8	0.0	2.1			
	None	47	69	65	181			
Market Opportunity	Better prices/more profits	9.8	3.1	2.7	15.6	37.838	8	0.000
	Steady supply	1.3	0.0	1.8	3.1			
	Safer environment	0.4	0.0	0.0	0.4			
	Customer satisfaction	2.7	0.0	0.0	2.7			
	increased markets	19.1	30.2	28.9	78.2			

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CONCLUSION

The data from this study concludes that edible termites are a delicacy in the study area owing to the majority of consumers across the wards, and although termites are still collected from the wild, the value chain actors ranging from input suppliers, especially the solar energy have played a key role in the collection of termites by providing a source of light, women, on the other hand, play a very vital role in the value chain right from production, processing, retailing to consumption, marketing of termites is done mostly on local markets which attract low prices especially during on season, this could be attributed to lack of market information in terms of demand and supply and prices they could get in other markets. Value addition to the product being sold to the market also seemed to be low as most traders sold fried termites at the market despite the various forms of value addition to insect-based food products. However, despite the value chain not being fully developed, there lies great potential in the commercialisation of termites as women retailers admitted to the fact that they got additional income from the sale of termites.

Recommendation

Edible insects (termites) have high market potentials, with demand often outstripping supply throughout the year; however, the value chain is impeded by its seasonality, lack of farmer groups and institutions, lending institutions, research and extension services, minimal value addition and inadequate market information. This study, therefore, recommends the need for government and policymakers to formalise the industry since its operation as an informal industry has limited its market potential. This would create a conducive environment for the industry to thrive as more actors will venture into the industry, and more support services and market information would be readily available to farmers.

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