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*Research Article*

# Current Knowledge and Perception of Edible Grasshopper/Locusts' Consumption in Western Kenya

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Edible insects play an important role as a protein source of high-nutritional value in the western region of Kenya. However, current knowledge on edible grasshopper/locust species consumed in western Kenya and the perception towards these insects as an alternative protein source are not well documented. A questionnaire was issued to 901 respondents in four counties of western Kenya. The results showed that 91.6% of the respondents had heard that grasshoppers/locusts are edible insects and that 51.2% of the respondents had consumed them. The most frequently identified edible species was *Cyrtacanthacris tatarica*, with 58.6% cases followed by *Schistocerca gregaria* (25.7%), while *Ruspolia differens* was the least identified (1.2%). The majority of the consumers (60.0%) were introduced to entomophagy by their relatives, fewer by their friends (34.0%), and 5.7% by themselves. For those who had never eaten them, 53.8% were unwilling to try, while 11.9% were willing. On availability in the market, 97.9% indicated having never bought, while only 2.1% had bought the insect. The highly preferred method of cooking was smoking/roasting at 53.3%. The majority at 50.1% indicated the willingness to rear, while 21.0% were undecided. The frequency of the respondents who highly preferred to rear the insect for food and feed was 50.4%. The results suggest that the study population has knowledge of edible grasshopper/locust species and is willing to rear edible insects as an alternative protein food source.

## 1. Introduction

The current world population of 7.6 billion is expected to reach 9.8 billion in 2050 [1]. This, therefore, means that food, especially in terms of proteins, needed to feed this growing population will also be doubled. However, as the population is increasing, greater pressure is being felt on agricultural land needed for food production as a result of human settlement and urbanization [2]. At the same time, overfishing and pollution of oceans and water bodies have decreased the production of fish as a protein food source [3]. Rapidly growing world population and the demand for animal protein in addition to the depletion of natural resources, therefore, require a quick rethinking of food patterns and habits, particularly those relating to meat or animal protein consumption. In recent years, there has been an increasing interest in the utilization of insects as a sustainable protein source and a way of tackling undernutrition, especially in developing nations [4]. The rising nutritional gap in the human diet and livestock feeds can therefore be filled by promoting edible insects as alternative high-quality protein sources for both human food and livestock feeds [5–7].

The consumption of edible insects has been a traditional practice in many countries around the globe since time immemorial [8]. Findings from researchers on the nutritional content of edible insects show that insects are rich in digestible proteins, vitamins, minerals, and fats which are quite comparable to that of vertebrate meat and hence essential for human consumption [9–12]. The deficiencies of micronutrients especially in pregnant women and undernourished children can therefore be prevented by including edible insects in their diet [13]. Consequently, edible insects have the potential to mitigate hunger and

undernutrition at the same time, playing an important role in improving rural livelihoods [12, 14].

The western region of Kenya is traditionally known for entomophagy, and grasshoppers and locusts are some of the insects which have traditionally been consumed in this region [15, 16]. It was, therefore, important to obtain insights into the current knowledge relating to the consumption patterns of grasshoppers/locusts, especially to encourage entomophagy in the current times of globalization. It is also believed that traditional communities where entomophagy is practised are well enriched with local knowledge of the edible insect species, methods of collection/harvesting, and preparation/cooking methods [17]; hence, it was important to find out this information from the respondents as well as their perception towards edible grasshoppers/locusts to document this knowledge.

Historically, grasshoppers and locusts (Orthoptera: Acrididae) have been associated with insect pests that destroy crops worldwide [4, 18]. However, they also have a great history of being used as human food in Africa, Asia, and the Southern USA [19]. They are rich in nutrients such as proteins, minerals, fiber, and fats [4, 20], which are comparable to that of conventional proteins such as eggs, meat, fish, and soybeans [21].

However, the culture of entomophagy has slowly been decreasing in the western region of Kenya due to factors such as globalization which has contributed to changes in people's habits and lifestyles, especially eating habits, hence making many people view insects with a lot of disgust and consider those consuming them as primitive [22]. Neophobia or fear of trying new foods is another factor contributing to a decrease in entomophagy where individuals avoid unfamiliar foods [21, 23]. At the same time, those that still consume them harvest the insects from the wild, and this is not sustainable since most insects are not available throughout the year [24]; there is also a risk of contamination from pesticides [25].

Although the western region of Kenya is traditionally known for entomophagy, there is scanty information on the current knowledge of the edible species of grasshoppers and locusts consumed and their consumption rate. Little effort has been made to documenting this rich knowledge of the grasshopper and locust consumption as an important traditional practice in the western region of Kenya. The current study therefore aimed to obtain insight into the current knowledge relating to the consumption patterns of grasshoppers/locusts and their potential to contribute substantially to human and animal nutrition. It is therefore important to document this traditional knowledge to restore and promote entomophagy so that this new information can be passed on, especially to new consumers [26] as well as used for future decisions related to entomophagy and insect domestication.

## 2. Materials and Methods

*2.1. Study Site and Sampling Design.* Questionnaires were administered to 901 households in four counties of western Kenya (Bungoma $n = 200$, Busia $n = 190$, Vihiga $n = 224$, and Kakamega $n = 287$). This region (Figure 1) was purposively selected for this study because entomophagy has traditionally been practised by inhabitants.

The target population included households residing in the western region of Kenya. The survey was conducted using face-to-face interviews. This method was preferred because the interviewers could instantly address the respondents' concerns and questions and give further clarifications. The method also enabled the use of grasshopper/locust photos, thus enabling the respondents to identify the edible species. Only one adult member per household was asked to answer the questionnaire. The survey was conducted during April and May 2021.

The survey sample was drawn using a multistage sampling procedure for each of the four counties found in western Kenya. A multistage sampling method was considered appropriate because a sampling frame with a complete list of all households in the study areas was not available.

Each of the four counties was divided into smaller administrative units called subcounties. Within each subcounty, a random sample of locations was drawn, from which several smaller administrative units (sublocations) were drawn. Within the sublocations, smaller units (villages) were randomly selected, which formed the primary sampling units. The secondary sampling units were the households, from which respondents were drawn. To select the households, every 3$^{rd}$ household along the main village road with a random start (either left or right) was interviewed. In case the targeted respondents were unavailable or uninterested in participating, the next randomly selected household was chosen to ensure that the desired sample size was realized.

*2.2. The Questionnaire.* A test of pretested questionnaires (S) with open- and close-ended questions was administered to respondents. The multiple-choice questions in this survey were adapted from [23] with few modifications. The questionnaire was divided into five sections. In the first section, sociodemographic information was collected. The second section contained questions related to general knowledge and familiarity about edible grasshoppers/locusts (the edible species, frequency of consumption, who was introduced to entomophagy, and readiness for new consumers to try). The third section had questions on the availability of grasshoppers/locusts (seasonality, availability in the market, and traditional methods of harvesting). The fourth part of the survey had questions on disgust and perception of grasshoppers/locusts as food and the preferred method of cooking. Each question item had statements measured on a 5-point Likert scale which was slightly modified [23]. The fifth and last section of the questionnaire was on the perceived acceptance of grasshoppers/locusts as food and feed (willingness to rear and the purpose for rearing).

*2.3. Data Entry and Analysis.* The completed questionnaire data were cleaned, and the information was verified and entered in an Excel sheet. Data were then coded in Statistical Package for Social Sciences (SPSS. version 20). To determine the statistical significance of the relationship between variables,


Figure 1: Survey study sites on grasshopper/locust consumption in western Kenya.

the data were subjected to chi-square goodness of fit analysis, and all data were considered statistically significant at $p < 0.05$. Microsoft Excel 2010 was used in generating pie charts.

## 3. Results

*3.1. Demographic Information of the Study Population.* The demographic characteristics of the study population in terms of age, gender, education level, and occupation are represented in Table 1. There were 901 questionnaires distributed in the study region. About 64.0% and 15.6% of the study population were in the age ranges of 18–40 years and 41–50 years, respectively. Male respondents were 51.6%, while females were 48.4%. In terms of literacy, a greater percentage had formal education (95.9%) and only a small percentage (4.1%) had no basic education. Most of the respondents were farmers (40.8%), followed by those who are self-employed (33.7%), while civil servants account for (8.2%).

*3.2. Knowledge, Familiarity, and Experience with Edible Grasshoppers/Locust Consumption.* The most frequently identified edible species based on the pictures presented to the respondents was *Cyrtacanthacris tatarica* (brown-spotted locust) (58.6%) followed by *Schistocerca gregaria* (desert locust) (25.7%), while *Ruspolia differens* (long-horned grasshopper) was least mentioned at 1.25% compared to the rest of the species (Figure 2).

It was critical to examine knowledge and experience about grasshopper and locust consumption in the western region of Kenya (Table 2). A greater percentage (91.6%) had heard that grasshoppers/locusts are eaten, while 8.4% did not know of them being edible. Those who had consumed were 51.2%, while 48.2% had never consumed, and hence, there was no significant difference ($\chi^2 = 0.04$ d.f. = 1 $p = 0.8415$). However, there was a difference in gender in association with consumption where more males (57.5%) than females (42.1%) had consumed grasshoppers/locust ($\chi^2 = 15.4$, d.f. = 3, $p = 0.0001$). Regarding the age of the participants who had consumed, there was also a significant difference such that a lower percent of 17.4% of the ages between 41 and 50 years had consumed, followed by the ages of 18–30 years at 23.6%. However, ages of 31–40 years and above 51 years had both consumed at 29.3%.

Table 1: Demographic information of the study population on grasshopper/locust consumption in western Kenya.

| Biodata | Attribute | Frequency | Percent |
|---|---|---|---|
| County of residence | Bungoma | 200 | 22.2 |
| | Busia | 190 | 21.1 |
| | Vihiga | 224 | 24.9 |
| | Kakamega | 287 | 31.9 |
| | Total | 901 | 100 |
| Age | 18–30 yrs | 316 | 35.1 |
| | 31–40 yrs | 260 | 28.9 |
| | 41–50 yrs | 141 | 15.6 |
| | >51 yrs | 184 | 20.4 |
| | Total | 901 | 100 |
| Gender | Female | 436 | 48.4 |
| | Male | 465 | 51.6 |
| | Total | 901 | 100 |
| What is your education level? | None | 37 | 4.1 |
| | Primary | 284 | 31.5 |
| | Secondary | 354 | 39.3 |
| | Tertiary | 226 | 25.1 |
| | Total | 901 | 100 |
| Occupation | Self-employed | 303 | 33.7 |
| | Student | 98 | 10.9 |
| | Farmer | 368 | 40.8 |
| | No job | 58 | 6.4 |
| | Civil servant | 74 | 8.2 |
| | Total | 901 | 100 |

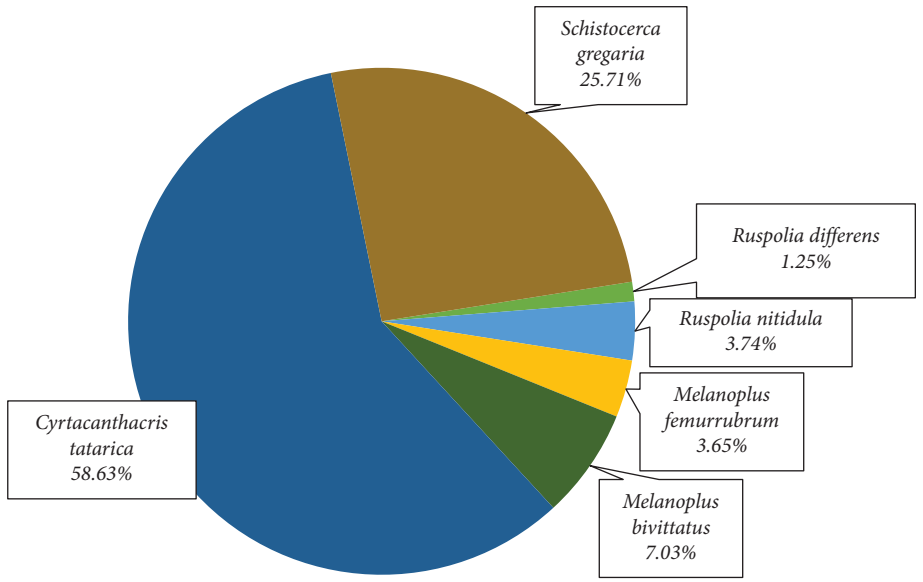


Figure 2: Percentage citations by respondents on knowledge of edible grasshopper/locust species in western Kenya.

Approximately 91.6% of the respondents liked consuming grasshoppers/locusts, whereas 8.4% never liked them. In terms of frequency of consumption, 43.7% indicated having consumed the insect on a few occasions. This was closely followed by 36.4% of the respondents who indicated that they only ate them when in season, while 19.9% said that they had consumed only on a single occasion. The majority of the respondents who had consumed grasshoppers/locusts were introduced to the culture of insect consumption by their relatives (60.3%), followed by those who were introduced to this culture by friends (34.0%), whereas those who introduced themselves were least at 5.7%.

To increase the acceptance of edible insects' consumption for new consumers, a significant proportion of the respondents (35.8%) were willing to consume if the insect is processed into flour and mixed in foods such as cakes and bread. Only 5.8% of the respondents who had not eaten

Table 2: Knowledge and consumption of edible grasshopper/locust in western Kenya.

| Question | Attribute | Frequency | Percent | Chi-square |
|---|---|---|---|---|
| Ever heard about people eating grasshoppers/locust? | Yes | 825 | 91.6 | $\chi^2 = 70.56$; d.f. = 1; $p < 0.0001$ |
| | No | 76 | 8.4 | |
| | Total | 901 | 100.0 | |
| Have you ever eaten/tried eating any before as part of your diet? | Yes | 461 | 51.2 | $\chi^2 = 0.04$; d.f. = 1; $p = 0.8415$ |
| | No | 440 | 48.8 | |
| | Total | 901 | 100 | |
| If yes, did you like it | Yes | 427 | 91.6 | $\chi^2 = 70.6$; d.f. = 1; $p < 0.0001$ |
| | No | 39 | 8.4 | |
| | Total | 466 | 100 | |
| If yes, how often have you eaten/tested them? | I have tried it on a single occasion | 92 | 19.9 | $\chi^2 = 8.9$; d.f. = 2; $p = 0.0113$ |
| | I have tried on a few occasions | 202 | 43.7 | |
| | I eat them when in season | 168 | 36.4 | |
| | Total | 462 | 100 | |
| Who introduced you to eating edible grasshoppers/locusts? | Friends | 154 | 34 | $\chi^2 = 43.76$; d.f. = 2; $p < 0.0001$ |
| | Relatives | 273 | 60.3 | |
| | Self | 26 | 5.7 | |
| | Total | 453 | 100 | |
| If not eaten before, would you consider trying eating them? | Yes | 52 | 11.9 | $\chi^2 = 26.48$; d.f. = 2; $p < 0.0001$ |
| | Maybe | 150 | 34.3 | |
| | No | 235 | 53.8 | |
| | Total | 437 | 100 | |
| If not eaten, would it help if the whole insect was for | Covered in chocolate | 35 | 10.7 | $\chi^2 = 29.15$; d.f. = 4; $p < 0.0001$ |
| | The whole insect mixed into food like rice | 19 | 5.8 | |
| | Ground and mixed in cakes and bread | 117 | 35.8 | |
| | Ground and mixed in porridge flour | 87 | 26.6 | |
| | Eaten as an extract, e.g., protein isolate | 69 | 21.1 | |
| | Total | 327 | 100 | |

edible grasshopper/locust pointed out that they would consume the whole insect mixed into food such as rice.

*3.3. Season of the Year of Grasshoppers/Locust Availability in Western Kenya.* The respondents were asked questions about the season of the year when grasshoppers/locusts are available (Figure 3). A good number of respondents cited the wet season (50.14%) as the time of the year when the population of grasshoppers and locusts is high, while 22.78% of the respondents felt that grasshoppers and locusts are more during the dry season. Only 1.9% of the respondents mentioned that grasshoppers/locusts were mostly seen throughout the year, while 10.79% had no idea when they are in season.

*3.4. Availability of Grasshoppers/Locusts in the Market in Western Kenya.* Respondents were also asked whether they had ever bought any edible grasshoppers/locusts before (Table 3). 97.9% indicated they had never bought these insects, while 2.1% had purchased the insect. Those who had never bought gave various reasons such as unavailability of the insects in the market (78.4%) and not willing to buy (14.0%), while few (5.0%) indicated they did not like the insects and thus could not buy them. There were significant differences in the responses about the willingness to buy grasshoppers/locusts if the insects were found being sold in the market ($\chi^2 = 17.2$ d.f. = 2, $p = 0.0002$).

Regarding gender and the willingness to buy edible grasshoppers/locusts, there was a significant difference where more males (64.2%) than females (35.0%) were willing to buy the insect if it was found being sold in the market ($\chi^2 = 29.9$, d.f. = 6, $p < 0.0001$).

*3.5. Knowledge of Harvesting Methods for Grasshoppers and Locusts in Western Kenya.* Various traditional methods used for harvesting grasshoppers and locusts were cited by the respondents (Figure 4). Handpicking (65.9%) was the most mentioned method, while other methods including chasing and catching (9.7%), beating with twigs (4.9%), use of sweep nets/traps (3.3%), and trapping with light (0.4%) were also mentioned though at lower frequencies. However, 15.8% of the respondents indicated that they had no idea how grasshoppers and locusts were harvested.

*3.6. Perception of Grasshopper and Locust Consumption in Western Kenya.* Respondents were assessed on their feeling about consuming edible grasshoppers/locusts as food (Table 4). They were provided with a Likert scale in which the first statement was that the idea of eating grasshoppers/locusts makes them feel nauseous in which the majority disagreed (69.1%), while a few (13.1%) agreed with the statement. A question on disgust was also asked, and a majority of the respondents disagreed with the statement that the idea of eating grasshoppers/locusts is disgusting (60.2%), with few (6.0%) strongly agreeing with the statement ($\chi^2 = 70.2$, d.f. = 3, $p < 0.0001$). Similarly, the majority of the respondents disagreed that if a grasshopper/locust crawls on their favourite food, they will not eat (67.9%), with few (6.2%) strongly agreeing ($\chi^2 = 100.7$, d.f. = 3, $p < 0.0001$). Similarly, the majority of the respondents disagreed with the statement that if a grasshopper/locust crawls on their favourite food, they would not eat it (67.9%), with few (6.2%) strongly agreeing with the statement. In the context of the taste of grasshoppers/locusts, 46.2% disagreed with the statement that grasshoppers/locusts have a bad taste, while 36.6% were neutral about the statement, but few (6.2%) strongly agreed with the statement. The respondents also gave their responses on the statement about grasshopper/locusts' consumption not being part of their culture. The majority (50.1%) disagreed with the statement that grasshopper and locust consumption is not part of their culture, 20.9% agreed, and 24.8% were neutral about the statement ($\chi^2 = 43.2$, d.f. = 3, $p < 0.0001$).

*3.7. Knowledge of Grasshopper and Locust Preparation Methods in Western Kenya.* Knowledge of different techniques for the preparation of grasshoppers and locusts for consumption was mentioned by the respondents (Table 5). Smoking/roasting was highly preferred by the respondents at 53.3% in contrast to the other methods of preparation ($\chi^2 = 79.4$, d.f. = 3, $p < 0.0001$). The preparation methods that were not preferred by the respondents at higher percentages include salting then boiling (85.5%), eating them raw (96.7%), and salting then deep-frying (62.0%). Similarly, on value addition of grasshoppers/locusts through grinding them into powder form and enriching foods such as porridge or bread, there was a significant difference in response among the respondents where only 18.1% moderately preferred, 4.3% highly preferred, and a higher percent of 46.5% did not prefer ($\chi^2 = 58.7$, d.f. = 4, $p < 0.0001$).

*3.8. Willingness and Reasons for Rearing Edible Grasshoppers/Locusts by Respondents in Western Kenya.* Respondents were asked whether they were willing to rear edible grasshoppers/locusts and the reasons for rearing if they were shown how to do so (Table 6). A majority of the respondents were willing (50.1%), while few were undecided (21.0%), but 29.0% were not willing to rear the insect. For those who were willing to rear, a majority (52.6%) indicated that they will rear them for multiple uses such as human food, animal feed, and for sale. The remaining respondents stated that they would rear them for single or dual uses as follows: for food only (3.8%), for feed only (2.8%), for both food and feed only (16.0%), and for sale (25.2%). The respondents also mentioned various forms of selling the insect to consumers as raw (48.2%), roasted (19.0%), fried (17.3%), both roasted and fried (4.4%), and also depending on the preference of the customer (11%) ($\chi^2 = 56.6$, d.f. = 4, $p < 0.0001$).

*3.9. Reasons for Rearing Edible Grasshoppers/Locusts.* Respondents were also asked to state the most preferred reasons for rearing grasshoppers and locusts (Table 7). Preferred reasons for rearing grasshoppers/locusts were pointed out as highly preferred for human food ($\chi^2 = 56.4$,

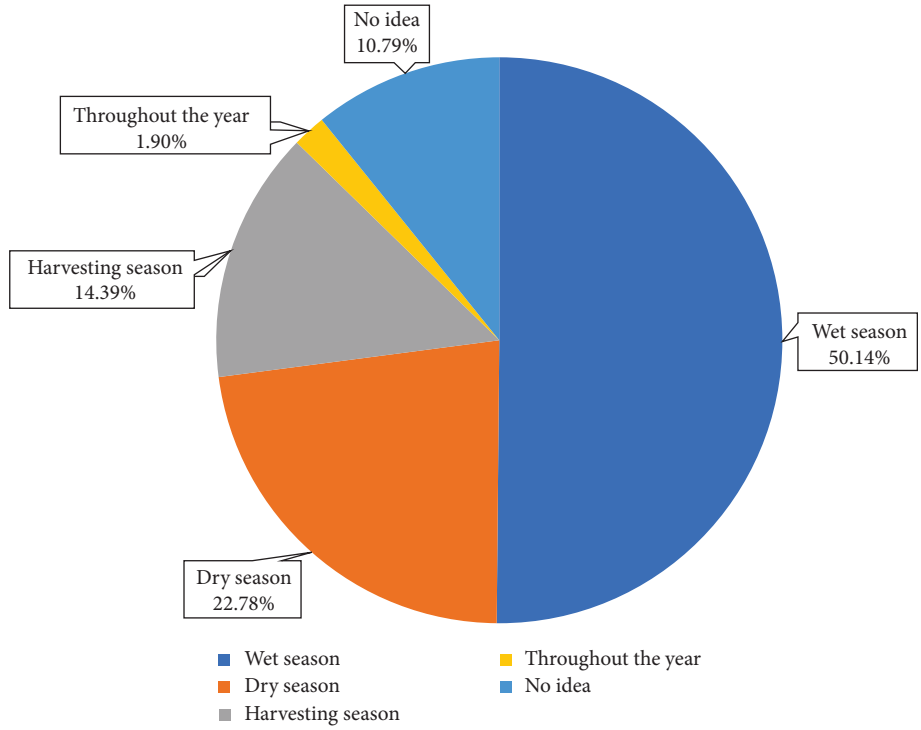


Figure 3: Seasonal occurrence of grasshoppers/locusts according to the respondents in western Kenya.

d.f. = 4, $p < 0.0001$) and chicken ($\chi^2 = 184.2$, d.f. = 4, $p < 0.0001$) but did not prefer to rear for livestock feed ($\chi^2 = 54.5$, d.f. = 4, $p < 0.0001$) and feed for pets and museum animals ($\chi^2 = 60.9$, d.f. = 4, $p < 0.0001$). Respondents were not decided on whether to rear edible grasshoppers for fish feed ($\chi^2 = 2.7$, d.f. = 4, $p = 0.6092$).

## 4. Discussion

*4.1. Knowledge, Familiarity, and Experience with Edible Grasshoppers/Locust Consumption.* The study examined knowledge about grasshopper/locust consumption in western Kenya. The study revealed that most respondents (91.6%) from western Kenya have knowledge about grasshoppers and locusts as being edible and that 51.2% have ever consumed them at one point in their life, while others are still using them for consumption. More males than females had consumed or are still consuming the edible grasshopper/locust. A study conducted by Bao and Song [27] shows males to be more adventurous and always ready to try new foods, while women mainly associate insects with uncleanliness and hence develop a fear towards insect consumption. The current observation is consistent with an earlier study undertaken by the authors in [16, 28] who indicated that grasshoppers and locusts are part of the traditional menu in the western part of Kenya and people still consume this insect.

Concerning the edible grasshoppers/locusts known to the study population, the majority identified *Cyrtacanthacris tatarica* (the brown-spotted locust) followed by *Schistocerca gregaria* (desert locusts) as the most preferred edible species. These findings correspond with the findings of the authors in [29], who also through their survey study in Muranga and Kilifi counties of Kenya showed the brown-spotted locust as a common edible grasshopper species. In Cameroon, the brown-spotted locust is also the most commonly consumed species [30]. Contrary to our expectation, *Ruspolia differens* (the long-horned grasshopper) was least identified as being edible even though a study conducted by the authors in [16] indicated that long-horned grasshoppers (senene) are commonly consumed in the western part of Kenya. The respondents did not consider the long-horned grasshopper species as being edible because they had some cultural beliefs attached to it. Culturally, the sampled region considers long-horned grasshopper as an insect that brings them good luck once it lands on their homestead, and that is why they do not consume them. However, the few respondents who had ever consumed the long-horned grasshoppers were mostly Ugandans found at the Kenya and Uganda Busia border. Nonetheless, long-horned grasshoppers are widely harvested and consumed in Zambia and regions around Lake Victoria, including Tanzania and Uganda [16, 31, 32].

The current rate or frequency of edible grasshoppers/locust consumption in the sampled region, however, was low since only 36.4% of the respondents still consume. The respondents gave various reasons for the decline in consumption. One of the reasons the majority gave was that grasshoppers/locusts are only available at certain times of the year, and when available, their population is very low; hence, they are not enough for consumption. A study by Abdullahi et al. [22] and Arena et al. [24] also reveals that the availability of edible insects is seasonal since they are only available at certain times of the year, posing a major challenge that hinders their consumption by many insect

Table 3: Participants' response towards the purchase of edible grasshoppers/locusts in western Kenya.

| Question | Attribute | Frequency | Percent | Chi-square |
|---|---|---|---|---|
| Have you ever bought any edible grasshoppers/locusts before? | Yes | 19 | 2.1 | $\chi^2 = 92.2$; d.f. = 1; $p < 0.0001$ |
| | No | 882 | 97.9 | |
| | Total | 901 | 100 | |
| If no what could be the reason for not buying | Not available in the market | 692 | 78.4 | $\chi^2 = 152.6$; d.f. = 3; $p < 0.0001$ |
| | Not willing to buy | 124 | 14.0 | |
| | Are available freely in nature | 23 | 2.6 | |
| | I do not like them | 44 | 5.0 | |
| | Total | 883 | 100 | |
| If no and you come across them in the market, will you consider buying them? | Yes | 260 | 29.3 | $\chi^2 = 17.2$; d.f. = 2; $p = 0.0002$ |
| | Maybe | 168 | 19.0 | |
| | No | 458 | 51.7 | |
| | Total | 886 | 100 | |

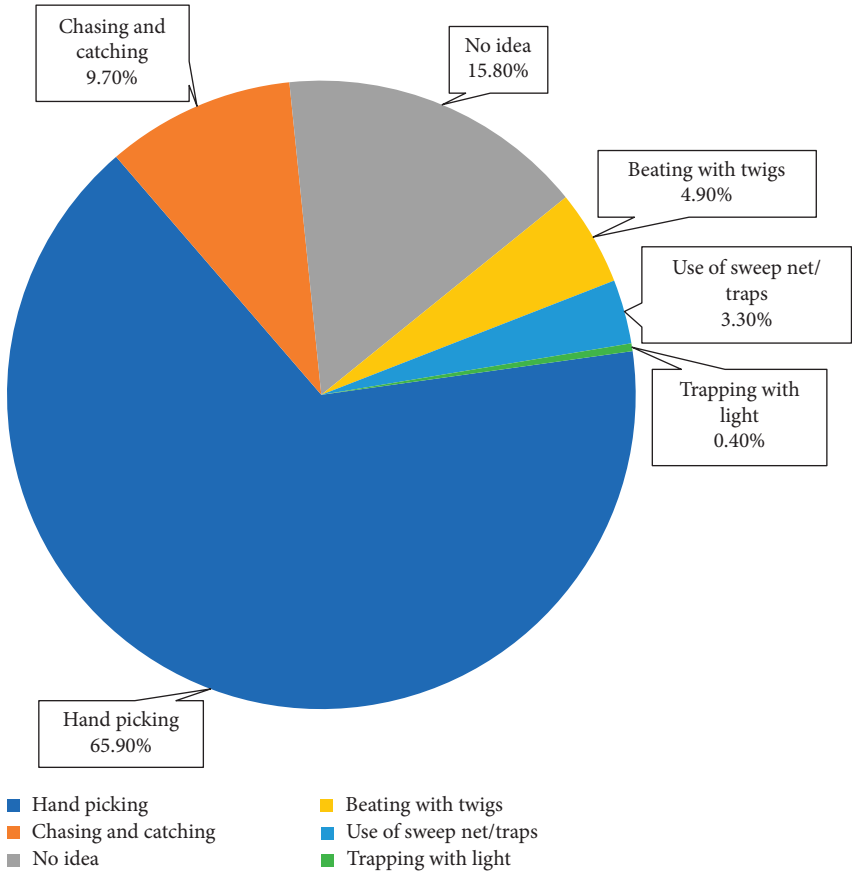


Figure 4: Knowledge of grasshopper/locust harvesting methods according to respondents in western Kenya.

consumers. Some respondents also explained that pesticides used in farming practices have chemicals that induce toxic residues in grasshoppers and locusts when they consume these crops and therefore pose a health risk to them if they consume the insects that have fed on such crops. This response is also in line with the findings of the authors in [25], who also had the same view on the reasons for the reduced consumption of edible insects across the world. Other respondents cited a lack of interest and fear in trying new foods such as insects. This response is supported by the authors in [22], who in their study cited a lack of interest as one reason for the decline in entomophagy in many populations across the world.

The majority of the respondents in western Kenya who had consumed grasshoppers and or locusts said that their relatives, that is, grandparents, uncles, or aunties, introduced them to the culture of edible insect consumption. These findings are consistent with the review study conducted by Hlongwane et al. [33], who agree that the older generation in the community will pass the knowledge and information about edible insects to the younger generation. Those who introduced themselves to grasshopper/locust consumption explained that it was out of curiosity at their younger age that made them eat the insect. In their study, the authors in [34] also stated that the curiosity of consumers about edible insects revolves around the novelty and taste of the insect and this factor can motivate a consumer to try and accept insect food.

The study examined the readiness to adopt insects in a diet for the respondents who had never consumed grasshoppers/locusts. Only 11.9% of the respondents indicated to be ready to consume grasshoppers/locusts as a food product, while another 34.3% were undecided. Even though these numbers are not large, they indicate the readiness and willingness of new consumers to try to consume grasshoppers/locusts as an alternative protein source. The willingness of new consumers to try and consume processed and value-added insect products that make the insect more appealing and palatable was also higher. Incorporating edible insects into familiar products such as biscuits, bread, and pasta makes the product more acceptable to consumers [22, 24], and it increases convenience to the consumer, hence reducing psychological barriers to its acceptance [35]. The majority of new consumers were more willing to consume the insect that has been ground into powder and mixed in foods such as cakes, bread, and porridge. The respondents felt that the processed insect is invisible, and hence, this will increase their chances of consumption. These responses are in line with those of the authors in [36, 37], who pointed out that consumers with no previous experience with insect consumption tend to consume edible insects in processed forms since the insect becomes invisible, hence reducing disgust associated with the consumption of the whole insect. The processed insect also increases the satisfaction

Table 4: Perception of grasshopper and locust consumption in western Kenya.

| Question on disgust and perception | Strongly agree | Agree | Neutral | Strongly disagree | Disagree | Total (%) | Chi-square ($\chi^2$) |
|---|---|---|---|---|---|---|---|
| The idea of eating grasshoppers/locusts makes me nauseous | 81 (9) | 118 (13.1) | 78 (8.7) | 1 (0.1) | 623 (69.1) | 901 (100.0) | $\chi^2 = 154.6$, d.f. = 4, $p < 0.0001$ |
| The idea of eating grasshoppers/locust makes me sick | 59 (6.5) | 94 (10.4) | 97 (10.8) | — | 651 (72.3) | 901 (100.0) | $\chi^2 = 118.2$, d.f. = 3, $p < 0.0001$ |
| Eating grasshoppers/locusts is disgusting | 54 (6) | 184 (20.4) | 121 (13.4) | — | 542 (60.2) | 901 (100.0) | $\chi^2 = 70.2$, d.f. = 3, $p < 0.0001$ |
| If a grasshopper/locust crawls on my favourite food, I will not eat it | 56 (6.2) | 140 (15.5) | 93 (10.3) | — | 612 (67.9) | 901 (100.0) | $\chi^2 = 100.7$, d.f. = 3, $p < 0.0001$ |
| I fear that grasshopper/locust-based food has a bad taste | 32 (3.6) | 96 (10.7) | 357 (39.6) | — | 416 (46.2) | 901 (100.0) | $\chi^2 = 55.1$, d.f. = 3, $p < 0.0001$ |
| I believe eating grasshoppers/locust is not part of our culture | 39 (4.3) | 188 (20.9) | 223 (24.8) | — | 451 (50.1) | 901 (100.0) | $\chi^2 = 43.2$, d.f. = 3, $p < 0.0001$ |

Numbers in brackets are in percentages.

Table 5: Knowledge of grasshopper/locust preparation methods according to the respondents in western Kenya.

| Cooking methods of edible grasshoppers | Highly preferred | Significantly preferred | Moderately preferred | Least preferred | Not preferred | Total (%) | Chi-square ($\chi^2$) |
|---|---|---|---|---|---|---|---|
| Eating them raw | — | — | — | 30 (3.3) | 871 (96.7) | 901 (100.0) | $\chi^2 = 88.4$, d.f. = 1, $p < 0.0001$ |
| Salting, then boiling | 1 (0.1) | 4 (0.4) | 22 (2.4) | 104 (11.5) | 770 (85.5) | 901 (100.0) | $\chi^2 = 277.5$, d.f. = 4, $p < 0.0001$ |
| Salting, then deep-frying | 57 (6.3) | 62 (6.9) | 62 (6.9) | 161 (17.9) | 559 (62.0) | 901 (100.0) | $\chi^2 = 115.1$, d.f. = 4, $p < 0.0001$ |
| Smoking/roasting | 480 (53.3) | 86 (9.5) | 109 (12.1) | 22 (2.4) | 204 (22.6) | 901 (100.0) | $\chi^2 = 79.4$, d.f. = 3, $p < 0.0001$ |
| Ground and mixed with flour (for porridge, bread) | 39 (4.3) | 64 (7.1) | 163 (18.1) | 216 (24.0) | 419 (46.5) | 901 (100.0) | $\chi^2 = 58.7$, d.f. = 4, $p < 0.0001$ |

Numbers in brackets are in percentages (%).

Table 6: Willingness to rear edible grasshoppers/locusts by the respondents in western Kenya.

| Questions on perceived acceptance of edible grasshoppers as food and feed | Attribute | Frequency | Percent (%) | Chi-square ($\chi^2$) |
|---|---|---|---|---|
| If you are shown how to rear grasshoppers/locusts, would you rear them? | Yes | 451 | 50.1 | $\chi^2 = 13.4$, d.f. = 2, $p = 0.0012$ |
| | Maybe | 189 | 21 | |
| | No | 261 | 29 | |
| | Total | 901 | 100 | |
| What will be your purpose for rearing them? | For food only | 22 | 3.4 | $\chi^2 = 85.4$, d.f. = 4, $p < 0.0001$ |
| | For feed only | 18 | 2.8 | |
| | For feed and food only | 103 | 16 | |
| | For sale | 162 | 25.2 | |
| | For food, feed, and sale | 338 | 52.6 | |
| | Total | 643 | 100 | |
| If you were to rear and sell them, in what form will you sell them? | Raw | 284 | 48.2 | $\chi^2 = 56.6$, d.f. = 4, $p < 0.0001$ |
| | Roasted | 112 | 19 | |
| | Fried | 102 | 17.3 | |
| | Roasted as well as fried | 26 | 4.4 | |
| | Any depending on the market | 65 | 11 | |
| | Total | 589 | 100 | |

Table 7: Reasons for rearing grasshoppers/locusts according to preferences by respondents in western Kenya.

| Reasons | Highly preferred | Significantly preferred | Moderately preferred | Least preferred | Not preferred | Total (%) | Chi-square ($\chi^2$) |
|---|---|---|---|---|---|---|---|
| Food for man | 324 (50.4) | 88 (13.7) | 77 (12.0) | 72 (11.2) | 82 (12.8) | 643 (100.0) | $\chi^2 = 56.4$, d.f. = 4, $p < 0.0001$ |
| Feed for livestock (e.g., cattle) | 49 (7.6) | 74 (11.5) | 89 (13.8) | 117 (18.2) | 314 (48.8) | 643 (100.0) | $\chi^2 = 54.5$, d.f. = 4, $p < 0.0001$ |
| Feed for chicken | 462 (71.9) | 147 (22.9) | 18 (2.8) | 3 (0.5) | 13 (2.0) | 643 (100.0) | $\chi^2 = 184.2$, d.f. = 4, $p < 0.0001$ |
| Feed for fish | 131 (20.4) | 150 (23.3) | 126 (19.6) | 88 (13.7) | 148 (23.0) | 643 (100.0) | $\chi^2 = 2.7$, d.f. = 4, $p = 0.6092$ |
| Feed for pets and museum animals | 52 (8.1) | 91 (14.2) | 100 (15.6) | 75 (11.7) | 325 (50.5) | 643 (100.0) | $\chi^2 = 60.9$, d.f. = 4, $p < 0.0001$ |

Numbers in brackets are in percentages (%).

of new consumers, hence reducing psychological barriers to its acceptance [35].

However, in the current study, some respondents who had never consumed grasshoppers/locusts still insisted that they were not willing or interested to consume. The choice not to eat grasshoppers/locusts in this study is therefore primarily influenced by having no interest as well as fear, and this was also pointed out by the author in [23] in his study. The authors in [24] also stated that the reluctance of new consumers to accept insects as food is attributed to a lack of interest in trying novel foods.

*4.2. Availability in the Market, Seasonal Occurrence, and Harvesting Methods for Grasshopper/Locust.* The availability of edible insects is one main factor that may determine their consumption. The study population had never seen grasshoppers/locusts being sold in the market and hence never bought them. In Kenya, it is very uncommon to find grasshoppers and locusts being traded in local markets or sold as snacks on roadsides. The majority of the respondents indicated that even if grasshoppers/locusts were sold in the market, they will not buy them since they can get them from the wild. However, termites (*Macrotermes sp*.), which are another edible insect commonly consumed in western Kenya, are commonly seen being sold in open markets in most parts of the region whenever they are in the season [38]. Even though grasshoppers/locusts are not openly sold in Kenya, long-horned grasshoppers are commonly sold along the roadside, in markets, and supermarkets in Uganda and Tanzania [32], and in Cameroon, they are also sold openly in markets and streets where consumers can access them easily [39].

Most respondents cited that grasshoppers and locusts are normally in plenty during the long rainy season since this is the time when green vegetation which is their food is in plenty and there is more foliage, thus leading to their high population. This response is in line with the study by authors in [40], who cited that grasshopper and locust diversity and population increase with an increase in vegetation.

The methods used to harvest grasshoppers and locusts vary throughout the world. The traditional methods of harvesting grasshoppers/locusts were pointed out by respondents as majorly manual through chasing and handpicking and sometimes beating with twigs mostly performed in the morning when the insects are less mobile and in season. These methods are also similar to those used in other countries, for example, West Nigers [5] and Mexico [41]. A few of the respondents mentioned light traps and sweep nets as methods of harvesting grasshoppers and locusts. Around Lake Victoria basin region, that is, Uganda and Tanzania, long-horned grasshoppers (senene) when in season are normally harvested on a large scale through light traps mostly at night [32]. In Madagascar, they are harvested by pulling big sheets over the vegetation or collected at night using torchlight when the insects are resting on shrubs or trees [42]. Despite various methods used in harvesting grasshoppers and locusts around the world, the main objective of harvesting them for consumption is always achieved by those involved in harvesting.

*4.3. Perception, Preparation Methods, and Willingness to Rear Insects as an Alternative Protein Source.* The majority of the study population believes that the consumption of grasshoppers/locusts is part of their culture. This reply is in line with the authors in [43], who indicated that grasshopper/locust consumption is part of the culture in the western region of Kenya.

Tradition and culture influence the cooking methods of edible insects, and not knowing how to prepare edible insects for consumption can negatively influence acceptance, especially to new consumers [34]. Insects can be consumed as fried, roasted, sun-dried, smoked, or powdered and consumed with porridge [25, 33]. The present study shows that smoking/roasting was highly preferred as compared to other methods of cooking such as boiling, salting, and deep-frying as well as consuming them in raw form. The methods of cooking may also differ in different regions of the world. In Togo, after locusts have been harvested, they are cleaned and boiled after which they are sun-dried on mats [44], while in Cameroon, grasshoppers for consumption are prepared by first boiling them in water until they turn yellow or brown, or orange, in colour; then, later on, they are fried with salt, onion, pepper, tomato, and celery [44].

From the study, the majority of the respondents were willing to rear the insects as an alternative protein source. More males than females were willing to rear grasshoppers/locusts, and this could be because men tend to be more adventurous when trying new food products [45]. At the same time, more farmers than those in occupations such as civil servants and self-employed were more willing to venture into insect farming. This could be attributed to the fact that farmers are already into farming practices, and therefore, venturing into insect farming as an additional venture would be easily acceptable to them.

Apart from grasshoppers/locusts being used as food and feed, they are also believed to have health benefits. For example, in Mexican culture, it has been reported that crushed hind legs from *Sphenarium spp*, *Taenipoda spp*, and *Melanoplus spp* grasshoppers are diluted and drunk as a diuretic as well as a treatment for some intestinal disorders. *Schistocerca species* are also consumed as a dietary supplement to cure nutritional deficiencies [25]. In the current study, some respondents in our discussion also associated *Schistocerca species* (desert locusts) with medicinal purposes. According to the respondents, the thorax is roasted and crushed, and its ash is used to treat colds and flu. However, most of these claims are based on traditional knowledge since there are no clinical data or chemical investigation that has been reported to support the claim.

The limitation of the current study was that there could be more edible species of locusts and grasshoppers which the respondents could have identified since the study relied on the picture catalog of some grasshoppers and locust species for identification. Despite the limitations, the study provides

valuable current information on the most preferred and consumed edible species and the willingness of the respondents to practice entomophagy through rearing the insect as an alternative protein source.

## 5. Conclusion and Recommendation

Our survey revealed that the population of the western region of Kenya had knowledge of the edible grasshoppers/locust species and that insect consumption is still part of their culture. The willingness of new consumers to try new foods, that is, edible insects, indicates that entomophagy is still acceptable in the western region of Kenya.

To promote the consumption of grasshoppers/locusts as food and feed, there should be quality and quantity production. Innovative methods of rearing them at a lower cost should therefore be introduced to consumers. This will improve the availability of edible grasshoppers and locusts throughout the year and hence contribute to the development of insect value chains. Reducing the negative perception of grasshoppers/locusts as food through value addition to the insect in the form of flour is a promising alternative to increase acceptance and introduce insect-based foods into the diet of Kenyans. For people still with insect food neophobia, consumer attitudes can be changed by organizing tasting and information sessions to change consumer attitudes.

## Data Availability

The data used in this manuscript are available on request from the first author.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

## Authors' Contributions

Sylvia Mmbone was responsible for conceptualization, investigation, methodology, data entry, formal analysis, writing the original draft, and writing, reviewing, and editing. Linnet Gohole was responsible for conceptualization, methodology, visualization, supervision, and writing, reviewing, and editing. Fredrick Wanjala was responsible for conceptualization, supervision, and writing, reviewing, and editing.

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## Supplementary Materials

The supplementary material on the questionnaire (S) can be downloaded at the following: https://drive.google.com/drive/folders/1VG2rh3zLPVXMJFFNW05709T7QJgZxAl7?usp=share_link. (*Supplementary Materials*)

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