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ASSOCIATION BETWEEN CONSUMPTION OF EDIBLE INSECTS WITH DIETARY DIVERSITY, AND HOUSEHOLD FOOD AND NUTRITION SECURITY IN SOUTHERN ZIMBABWE

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ABSTRACT

Edible insects are nutritious with potential to improve nutritional outcomes and livelihoods in low-income countries. However, it is not clear whether consumption of edible insects is positively correlated with improved dietary diversity and food security indicators. Therefore, this cross-sectional study was designed to investigate the relationship between consumption of edible insects and diet diversity and food security indicators among children and adults from Gwanda district, Matabeleland province in Southern Zimbabwe. The survey collected data on the following; household sociodemographic characteristics, household dietary diversity score (HDDS), food consumption score (FCS), and child dietary diversity score (CDDS). Logistic regression was used to examine the associations between edible insect consumption and food security indicators. A total of 303 households were surveyed. A high proportion were edible insect consumers (80.9%) and the rest non-consumers (19.1%). The most consumed insect was mopani worms (*Gonimbrasia belina, madora, amacimbi)* (74.8%). The consumption of mopani worms was highest in the age group 20-49 years (34.4%) and significantly associated with being married and age of the household head. There was no difference between the mean CDDS for consumers (5.9±1.7) and for non-consumers (6.0±2.0) (p=0.802). The median (IQR) FCS for consumers was lower at 49 (35, 65) than for non-consumers 53 (36.5, 64). This difference was not statistically significant (p=0.526). There also was no difference between the average HDDS for consuming households (6.2±1.7) and for non-consuming households 6.2±1.5 (p=0.866). There was no significant association between consumption of edible insects and CDDS (p=0.802), HDDS (p=0.866), and FCS (p=0.585). In conclusion, this study showed that *Gonimbrasia belina* (mopani worms, *madora, amacimbi*) were the commonly consumed insect mostly as relish due to their palatable taste. Overall, the consumption of edible insects did not seem to improve diet diversity and food security indicators in this setting. National level studies with bigger sample sizes that investigate the contribution of edible insects to overall nutrient intake and dietary diversity are required. Furthermore, interventions to promote the consumption of edible insects, including their commercialization should adopt a social ecological approach to maximise impact.

Key words: Entomophagy, food security, mopani worms, stunting, gender, Zimbabwe

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INTRODUCTION

Edible insects are widely consumed as an alternative source of protein mostly in Africa, Latin America, China, Thailand, Japan, and among Australian Aborigines [1]. Globally, there is documented evidence of over 2000 edible insect species regarded as source of nutrition, as food and feed [2, 3]. Edible insects have an important role towards attainment of resilient food security. In addition, they are nutrient dense and provide associated health benefits central to improving global food and nutrition security [4]. This is in line with the current United Nations (UN) global food systems transformation agenda's growing call to transform food systems towards sustainable, just and healthy systems [5]. Despite these positives, there are also concerns about the safety and allergenicity of edible insects. These include microbial contamination, heavy metals accumulation and synthesis of chemical contaminants such as toxins [6]. Therefore, the long-term benefits must be weighed against these safety concerns and other global trends such as population growth and food insecurity.

The expanding global population generates several challenges related to food production, food and nutrition security, land use, resource management, and environmental impacts. In addition, the global protein source requirements are also increasing, and this highlights the urgent need for alternative protein rich sources [7]. Considering that the world's population is projected to reach 9.7 billion by 2050 [8] ensuring food security for all remains a critical challenge for policy makers. Based on these projections an increase in agricultural production of 25%–70% is necessary to meet the cereal food security demand in 2050 [9]. Globally consumption of meat protein is expected to increase by 14% by 2030 also due to population expansion and increased incomes [10]. Edible insects due to their environmentally friendly production systems and rich nutrition profiles have potential to be an alternate source of sustainable protein [11, 12]. As such edible insects have gained popularity as alternative food resources in the face of climate change when compared to the increasing carbon and environmental footprints associated with conventional crop and livestock production systems [13]. For example, insects require less land and have a lower environmental impact than meat products [14].

In Zimbabwe approximately a third of the rural households experience perennial food insecurity associated with climate change induced low agricultural productivity [15]. As part of sustainable and resilient food systems the consumption of edible insects has the potential to contribute to household food security. However, there is low consumption of edible insects, mostly in urban areas despite them being good sources of protein and key micronutrients in the country [16]. Some rural districts in Zimbabwe contain populations that predominantly consume edible insects, the most commonly consumed being *Gonimbrasia belina* [16], however there is limited information regarding their contribution to the diet and to food and nutrition security [17]. Therefore, this study investigated the relationship between consumption of edible insects and selected food and nutrition security indicators among children and adults from Gwanda District, a mopani worm consuming region in southern rural Zimbabwe.

MATERIALS AND METHODS

The study was conducted in Gwanda District the capital of Matabeleland South province, Southern Zimbabwe in April 2021 (Figure 1). Gwanda was selected as the study site based on the abundance of mopani worms (*Gonimbrasia belina*) in the district. The district of Gwanda is made of 24 administrative wards. Not all administrative wards are mopani worm consuming. After interviews with locals four administrative wards were purposively selected (Wards 14, 16, 21, and 22) for the survey.

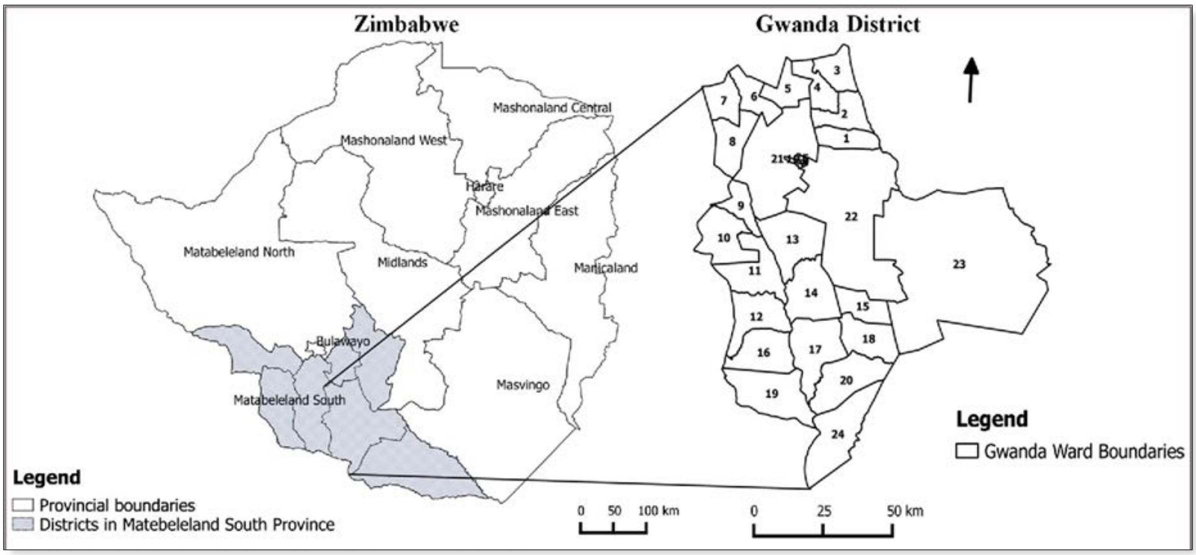

Figure 1: Enumeration areas for the study

This study was designed as a cross sectional study to determine prevalence and acceptability of mopani worm consumption in preparation for a randomized controlled trial (RCT) to test the efficacy of mopani worm based porridge on micronutrient status and growth of primary school children. Considering the limited body of evidence in this focus area, this baseline study will provide empirical evidence to guide design of the RCT and future studies.

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The study enrolled households in the target setting to explore trends in the consumption of edible insects across the life course; children (6-59 months), school age children (5-9years) and adolescents (10-19 years) and adults 20 years and older. However, the sampling unit was household and the interviews were conducted with the household head. The sample size was calculated using the Dobson formula as follows. Using a p (proportion of households that consume mopani worms) of 0.77 based on the Zimbabwe Vulnerability Assessment Committee (ZimVAC) 2020 report [18] and a Z^2 value of 3.84, confidence value of 0.0025 with a non-response rate of 10%, a total of 299 households were sampled. From each of the four wards selected, four enumeration areas (EA) were selected using the random generator function in Microsoft Excel. In each EA, 19 households were selected to make up a total of 304 households. Households were identified using systematic random sampling from the list provided in the village registers by first; randomly selecting the first household using the lottery method. This was followed by selecting subsequent households guided by a sampling interval dependent on the proportionate households determined by the number of households in the village registers.

Socio-economic and demographic characteristics were assessed based on sections extracted from a validated questionnaire used for national ZimVAC surveys [18]. The final questionnaire collected information on demographic and socio-economic characteristics, consumption of edible insects (type and frequency), dietary intake with a recall period of 24 hrs and 7 days for determining dietary diversity indicators (HDDS, DDS for children and FCS, respectively). The developed questionnaire was converted into an electronic version and uploaded on to android tablets using the Census and Survey Processing System (CSPro) application. All enumerators were given tablets with the electronic questionnaire. The questionnaire was administered by trained enumerators who used the local language. These enumerators were drawn from a database of enumerators who routinely conduct the nationwide ZIMVAC vulnerability assessment surveys. All responses were entered on to the electronic questionnaire using CSPro Data Entry, version 7.0.2 (U.S. Census Bureau, Maryland, USA). This questionnaire was linked to a server and data was immediately uploaded and saved on the server once it was collected.

Household Dietary Diversity Score (HDDS) reflects household access to food. Information on household food consumption was collected using the previous 24-hours as a reference period. Data for the HDDS indicator was collected by asking the respondent a series of yes or no questions concerning foods consumed in the previous 24-hours as described by FAO [19]. Respondents were instructed to recall foods consumed by household members in the home or prepared in the home for consumption by household members outside the home (example, at lunchtime in the fields) during the reference period [19]. A household is given a score if it consumed food from a food group listed. There are 12 food groups used to calculate the household dietary diversity score namely, (1) Cereals, (2) Roots and tubers, (3) Vegetables, (4) Fruits, (5) Meat, poultry, and offal, (6) Eggs, (7) Fish and seafood, (8) Pulse, legumes, and nuts, (9) Milk and milk products, (10) Oil/ fats, (11) Sugar/ honey and (12) Miscellaneous. The total number of food groups consumed by members of the household was then computed. HDDS score >5 is usually deemed acceptable or reflects adequacy.

While HDDS is a measure of household access to food, the individual dietary diversity measures nutritional quality for the individual. The questions are the same except that sugar and honey are not included as a food group in the list of food groups included in a CDDS indicator because this food group is not an important contributor to the nutritional quality of a child's diet. The child dietary diversity score was therefore assessed and calculated in exactly the same way as the HDDS minus one food group (sugar and honey). DDS for children was classified based on the scale: Deficient = DDS ≤4, Adequate= DDS ≥4.

Food consumption data was used to calculate food consumption scores (FCS) consistent with standard methodology [20]. The FCS were measured by collecting both consumption and frequency of different food groups by a household during the past 7 days before the survey. To calculate the FCS, standard weights were attached to each of the food groups that comprise the food consumption score. The food consumption groups include starches, pulses, vegetables, fruit, meat, dairy, fats, sugar. The consumption frequencies of the different foods in the groups were summed, with the maximum value for the groups capped at 7. The formula, based on these groups, with the standard weights, is: FCS = (starches*2) + (pulses*3) + vegetables + fruit + (meat*4) + (dairy*4) + (fats*.5) + (sugar*.5) [20]. The FCS ranges from 0 to 112 [18]. The FCS categorises were computed as follows: Poor = FCS 0-21, Borderline = FCS 21.1-35, Acceptable = FCS >35.

Data were entered onto tablets using CSPro data entry software (version 7.6.2, US Census Bureau). It was imported into SPSS for cleaning and analysis. Normality of distribution was checked using Shapiro-Wilk test and visualisation of QQ Plots. Descriptive statistics were computed. Differences between groups were tested using independent samples T-test and Mann-Whitney T-test for normal and non-normal data respectively. Pearson's Chi-Square was used to test for associations

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across categorical variables and Pearson for continuous normal data (consumption of edible insects and the following food security indicators-CDDS, HDDS, FCS). Determinants of edible insects' consumption were explored using binary logistic regression analysis with consumption of edible insects (Yes =1 and No =0) as dependent variable. The conditional reverse elimination approach in SPSS was used. For all tests unless otherwise stated the level of significance was set at $p < 0.05$.

RESULTS AND DISCUSSION

Consumption of edible insects has potential to fight hunger and food insecurity particularly in low-income settings [4]. Therefore, this study was designed to explore the relationships between consumption of edible insects and food security indicators among children and adults from Gwanda district in southern Zimbabwe.

Sociodemographic characteristics

A total of 303 households were surveyed. A high proportion were edible insect consumers (80.9%, n=245) and the rest non-consumers (19.1%, n=58) (Table 1). The average age of household head for the total surveyed households was 54.8±17 years. Age of household head was not statistically significantly higher in consuming households (55.2±16.1) than non-consuming households (54.2±18.5). Female headed households made up 40% of the total surveyed households. Majority (90%) of the total surveyed households were headed by members of the Apostolic Sect (religion) and 60% of the total surveyed household heads were of the Ndebele ethnic group (Table 1).

A higher proportion (80%) of consuming households were headed by a married couple compared to 50% in the non-consuming households (p=0.001). Household total income was higher in the non-consuming households (USD208.50) compared to consuming households (USD184.90). This difference was not statistically significant (p=0.275). Household size was significantly higher in consuming households (4.7±2.8) compared to non-consuming households (3.9±1.9) (p=0.001). These results contradict earlier findings by Manditsera *et al.* [17], who reported no correlation between socio-demographics and consumption of edible insects in Zimbabwe's rural settings. The finding that consumption of mopani worms was significantly associated with being married and age of household head is interesting. This agrees with earlier studies that also reported an increased consumption of edible insects among married household heads [21]. This is not surprising as these households will also be large as the number of dependents increases after marriage in African settings. This could be an indication that edible

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insects are being utilised as alternative and cheaper sources of protein in these households. In this respect edible insects have a key role to play in improving food security in low income settings [22]. This may explain why they are perceived as poor mans' food in some communities, which is a potential barrier to promoting their consumption particularly in urban areas.

The results (Figure 2) show that the biggest proportion of consumers was in the age group 20-49 years (34.4%), followed by 25.9% among adolescents (10-19 years) and then over 50 years (21.4%). It is also important to note that mopani worms are also being fed to infants and children; 0-59 months old (7.9%) and 5-9 years olds (10.5%). Interestingly, across all age groups consumption appears to be higher in males compared to females. However, this difference was not statistically significant (p=0.783). Overall, it has been observed in other settings that based on the food neophobia scale (FNS) males are more open to trying insects than females, and food neophobia was negatively correlated with the willingness to eat insects [23].

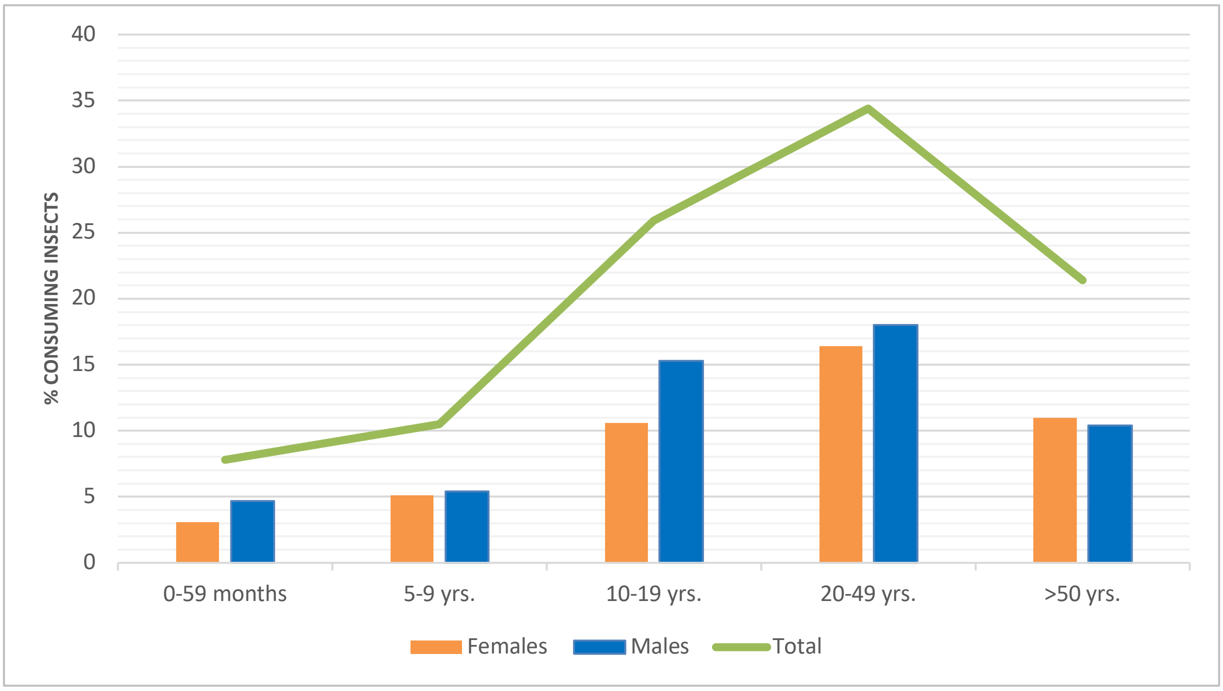

Figure 2: Insect consumption of study population by age group

Frequently consumed insects and motives to consumption

Table 2 shows that the most consumed insect was *Madora / Amacimbi / Gonimbrasia belina* (74.8%) followed by *Macrotermes spp*. (*Ishwa, inhlwa*) (5.4%). In addition, the mopani were frequently consumed for the following reasons; as relish (33.9%), taste (31.5%), nutritional value (13%) and availability (12.3%). The key motives for the consumption of edible insects (particularly the most consumed *Gonimbrasia belina*) was for relish (33.9%) and taste preference (31.5%). This agrees with earlier studies in Zimbabwe [16] and India [24], where respondents also reported that they found edible insects to be delicious. A greater proportion of the participants were introduced to edible insects by family members (49%) and self-interest (43.7%) respectively. This finding in this current study confirms that entomophagy (the practice of consuming edible insects) prevails in Southern Zimbabwe.

Entomophagy, dietary diversity and food security indicators

In the current study, the mean child dietary diversity for consumers was lower (5.9±1.7) than for non-consumers (6.0±2.0) (Table 3). However, there was no significant difference between consumers and non-consumers in child dietary diversity (p=0.802). The median food consumption score for consumers was lower at 49 (35, 65) than for non-consumers 53 (36, 5, 64). This difference was, however, not statistically significant (p=0.526). The average HDDS for consuming households was 6.2±1.7 and for non-consuming households 6.2±1.5. This difference was also not statistically significant (p=0.866). There was also no correlation between consumption of edible insects and child dietary diversity (p=0.802), household dietary diversity (p=0.866), food consumption score (p=0.585). Overall, the current results revealed that there was no correlation between consumption of edible insects and food and nutrition security indicators (child dietary diversity, HDDS, FCS). This finding appears to contradict the growing body of knowledge that edible insects are anchors of household food security and are important for the attainment of sustainable development goals (SDGs) on poverty, hunger, environment and health [21, 22]. Literature shows that edible insects' have protein and micronutrient profile that is comparable and sometimes higher than those of animal-derived foods [25]. Hence, entomophagy is a useful food-based approach that is feasible, sustainable, and cheaper to deliver nutritious foods to communities thus ultimately ensuring household food security. This lack of association could have been due to the low numbers of consumers especially among children. Insects are also mainly consumed as snacks and not as a main meal hence consumption levels could be too low and infrequent for us to detect an effect. Further, communities depend on wild harvesting for supply of edible insects which are seasonal in availability. Consuming households were bigger in size and had a lower income than non-consuming households. This may imply that insects are mostly consumed as a coping mechanism in households of low socio-economic status. However, this warrants further evaluation.

Determinants of edible insects' consumption

The binary logistic regression analysis revealed that being married increased the odds of consuming edible insects [OR=0.38, 95% CI: 0.15, 0.99 (p=0.047)]. This gender, link to consumption of edible insects was discussed in the previous section. The regression analysis seems to cement the notion that generally men are less sensitive to disgust than women [26] and tend to be more adventurous with food preferences compared to females [27]. Although trending, the age of household head was not a significant predictor of edible insect consumption [OR=0.98, 95% CI: 0.95, 1.0 (p=0.041)] (Table 4). In this study we did not find any significant association between edible insect consumption with gender, religion and educational level (p>0.05). Almost half of the population of consumers were introduced to edible insects by family tradition (49%), and age of household head was a predictor of consumption in this study. These results show the importance of utilising a social ecological model to understand the key facilitators and barriers to the consumption of traditional food including edible insects to guide promoting consumption [28]. This can be useful for the design of multilevel interventions (individual, family, community and national) to promote the consumption of edible insects within the framework of sustainable food systems.

Limitations

The study had some limitations. The study only focused on Gwanda, a rural based district, where consumption of edible insects tends to be higher than in urban areas [16]. One of the weaknesses of interviews is that participants tend to give socially acceptable responses [29]. Dietary intake assessment methods are based on respondent memory, and are therefore prone to recall bias [30]. Although, this study explored the food security aspects, the food safety and other health concerns were not well covered [31]. However, self-reported data on allergies revealed that this is not a key problem in this community.

CONCLUSION

This study showed that the most consumed insect (74.8%) was *Gonimbrasia belina (mopani/ madora / amacimbi)* which are mostly consumed as relish due to their palatable taste. The consumption of mopani worms was highest in the age group 20-49 years (34.4%) and significantly associated with being married. There was no association between consumption of edible insects and food security indicators (CDDS, HDDS, FCS). Future broader studies that will elucidate the contribution of edible insects to nutrient intake and food security are warranted. These studies must quantify actual/usual intake, describe variations within local food systems and in contrasting environments and analyse nutrient constitution of these edible insects for listing in food composition tables. Edible insects are part of non-timber forest food products, and these have not been analysed and included in most food composition tables. Furthermore, in this current study, approximately half of the participants reported that they were introduced to entomophagy by older family members. Therefore, interventions that are designed to promote the consumption of edible insects, including their commercialization in this and related settings should adopt a social ecological approach. This means that these interventions must not only focus on the interpersonal level such as peers and family influence but on multiple-level factors such as intra personal factors (motivation and skills), community level (such as community norms) and policy level (such as local laws to encourage breeding and conservation of edible insects).

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We would like to thank all participants for their time and valuable information that we gathered during data collection and the Gwanda District local authorities for approving data collection.

Ethics approval and consent to participate
The study was conducted according to the Helsinki ethical guidelines and WHO COVID-19 protocols. Ethical approval was obtained from the ethics committee of Marondera University of Agricultural Science and Technology (MUAST-006/21). Community approvals were obtained through process of consultative engagement. Informed Consent: Written informed consent was obtained from all participants.

Data availability statement
The anonymised database will be provided by the corresponding author on reasonable request.

Competing interests
The authors declare that they do not have any conflict of interest

Author contributions
PC and TM contributed to the conception, design of the study, data acquisition and analysis. They drafted the manuscript. FM, JM, SB, GK and LM contributed to the conception and design of the work as well as data acquisition. All authors read and approved the final manuscript.

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Table 1: Background characteristics of households by edible insect consumption status

Variable	Total (n=303)	Consume edible Insects Yes (n=245)	No (n=58)	Difference [Y-N]
Household Head				
Age (years)	54.8±16.9	55.2±16.1	54.2±18.5	0.93
Female%	40±0.5	40±0.5	40±0.5	-0.04
Married%	70±0.5	80±0.4	50±0.5	0.20***
Religion (Apostolic Sect) %	90±0.4	20±0.4	20±0.4	-0.05
Head Ethnic Group				
Ndebele%	60±0.5	60±0.5	60±0.5	-0.00
Education Primary%	10±0.4	10±0.3	20±0.4	-0.04
Household Size	4.4±2.6	4.7±2.8	3.9±1.9	0.807***
Total Income (USD)	185.9	184.9	208.5	-23.6
	[102.7, 308.1]	[102.7, 287.6]	[102.7, 410.8]	

Notes: The "difference" column shows the results of two-tailed t-test for the difference in the means for continuous variables and Chi Square for proportions, Mann Whitney for continuous non normal data

***, **, and * indicate the 1%, 5%, and 10% levels of significance

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Table 2: Insect consumption of study population

Variable	Frequency (n)	Percent (%)
Type of edible insects consumed		
Gonimbrasia belina (Mopani, Madora/Amacimbi)	249	74.8
Macrotermes spp. (Ishwa, inhlwa)	18	5.4
Carebara vidua (Tsambarafuta, Ihlabusi)	15	4.5
Locusta migratoria (Hwiza, Mhashu, Inthethe)	12	3.6
Macrotermes spp. (Majuru, Magenga)	4	1.2
Ruspolia differens (Tsumwarumwa, Inswabanda)	4	1.2
Brachytrupes membranaceous (Makurwe, Inyekevu)	3	0.9
Cerina forda (Harati)	1	0.3
Gonanisa maia (Magandari, intowa, inowa)	1	0.3
Eulepida Mashona (Mandere)	1	0.3
Acheta afer (Humbwe, Inyekevu)	1	0.3
Henicus whellani (Majenya)	1	0.3
Ioba leopardine (Nyenze, Inyeza)	1	0.3
Encosternum delegorgue (Harurwa, Umtshiphela)	1	0.3
Other	21	6.3
Reasons for consumption		
Relish	198	33.9
Taste	184	31.5
Nutritional Value	76	13.0
Availability	72	12.3
Tradition/custom	13	2.2

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Variable	Frequency (n)	Percent (%)
Easy to process	4	0.7
Medicinal properties	1	0.2
Easy to harvest	1	0.2
Other	35	6.0
Who introduced you to edible insects?		
Family tradition / Generational	170	49.7
Self interest	149	43.6
Relatives	14	4.1
Friends	9	2.6

Table 3: Food and nutrition security outcomes by consumption status of edible insects

Variable	Consume Edible Insects		p*
	(Yes)	(No)	
Dietary diversity Score for children (7-11yrs)[1]	5.9±1.7	6.0±2.0	0.802
Food Consumption Score[2]	49 [35, 65]	53 [36.5, 64]	0.526
Household Dietary Diversity Score[3]	6.2±1.7	6.2±1.5	0.866

Notes: *p-value for independent samples T-test and independent samples median test used for normal and non-normal data respectively. [1] n=125 for Yes and 22 for No. [2,3]n=245 Yes and 58 for No

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Table 4: Determinants of edible insect consumption among participants

	B	S.E.	P-value	Odds Ratio (OR)	95% C.I for OR Lower	Upper
Males	0.319	0.377	0.397	1.38	0.66	2.88
Household head age (years)	-0.024	0.012	0.041*	0.98	0.95	1.00
Married	-0.971	0.490	0.047*	0.38	0.15	0.99
Christianity	0.936	0.593	0.114	2.55	0.80	8.15
Secondary level education	0.478	1.106	0.665	1.61	0.19	14.11
Constant	-1.171	1.413	0.407	0.31		

Notes: *p-value significant at $p<0.05$, Nagelkerke R^2 = 0.076, Hosmer and Lemeshow Test (p=0.546)

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