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COMMERCIALIZATION OF ALATE TERMITES (*Macrotermes sp.*) TO IMPROVE HOUSEHOLDS' LIVELIHOODS IN VIHIGA COUNTY, KENYA

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ABSTRACT

To meet the rising demand for animal-based protein, conventional livestock may prove expensive as the current production system remains unsustainable. This calls for intervention research on alternative sources of protein, hence a switch to affordable and environmentally acceptable protein sources of which approximately 1,900 insect species are consumed worldwide. Alate termites have thus received considerations in this line for nutritional and economic benefits. Trading of alate termites is becoming a valuable source of income for many people in Vihiga county and other parts of western region, which although modest in terms of monetary value, could nonetheless form a significant proportion of their annual income. Information about commercialization of alate termites and its impact to household level food security has remained sparse. The goal of this research was to partly fill this knowledge gap and document the associated potential of alate termite commercialization on household livelihoods in Luanda and Hamisi sub-counties of Vihiga county. A total of 204 respondents participated in the cross-sectional study. Chi Square and regression analysis was employed to predict association and relationship between alate termite collection and marketing and household income for improved livelihoods. The results affirmed that, alate termites are a delicacy and cultural food eaten by the majority of the people in western Kenya. This is attributed to its nutritional value as well as higher economic potentiality. The average retail price per kilogram of 500 Kenya Shillings (US $5), compares favorably with that of goat meat, which is retailed within the region. The trading of alate termites is dominated by women and characterized by wholesalers who buy the alates from collectors and sell to retailers. The purpose of utilization was positively significant $p<0.005$. Inferring that the benefits realized from utilization of alate termites was dependent on households' decisions regarding various utilization purposes. Drying was the most common preservation method (64%) whereas others have a preference for frying. Moreover, alate termites are grounded into flour that is used for baking other products. The potential of alate termites to diversify household livelihood can be fully explored in order to contribute to household livelihoods and ultimately food security.

Key words: Household Livelihood, Alate termites, Marketing, Value addition, Utilization

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INTRODUCTION

The world is witnessing a rapid increase in demand for food especially animal based protein [1]. This is due to the increasing global population which is projected to reach 9 billion by the year 2050. The dilemma is on how to ensure the demand for animal-based protein is met in the face of climate change, environmental degradation and exploitation. Thus, entomophagy is gaining substantial attention in this line. Currently, over 1,900 insect species are consumed depending on their stage in the life cycle[2]. Entomophagy, the consumption of edible insect species, have been reported in Asia, Africa, North America, and Australia [3].

In Africa, edible insects are primarily harvested from the wild for food or livestock feed. However, in some parts of the continent, domestication of these edible insects such as crickets, black soldier fly, have been reported [2]. In recent years, scientists and communities in some countries have expressed an increased interest in harvesting insects for food and sale [2,4]. In several African countries, the consumption of insects is a part of many communities' traditions, with various species consumed as delicacies, important components of daily diets and as snacks. This is mainly owing to necessity rather than choice, as the climate and small-scale nature of animal husbandry reduce the amount of available animal protein, prompting an expansion of the diet to include insects. Additionally, consumption of soldier termites of the *Macrotermes sp.* in Zimbabwe as well as parts of sub-Saharan Africa and South Africa have been reported [5]. Nevertheless, various studies have shown that edible insects contribute positively to nutrition, health, environmental sustainability and household livelihood for those involved in the edible insect value chain, of which alate termites are among the edible insects that have gained substantial attention in terms of collection, marketing and consumption [2,6].

In Kenya, several insect species including the alate termites, grasshoppers, locusts, lake flies and crickets have been embraced as important parts of the diet [4,7]. These insects have received a boost due to increased research on their nutritional and economic potential However, some species of termites and grasshoppers, were often regarded as pests even though they have high nutritional qualities [8,9]. Alate termites (*Macrotermes sp.)* were considered better than the meat of mammals and birds [8], owing to the prestigious status of rich fat and protein, as well as fats that are more bioavailable than minerals from plant foods [5,10]. This makes termites useful in curbing nutritional deficiency in various parts of the world [7,11].

Collection and consumption of termites has been reported in greater parts of Western Kenya that forms the study region with alate termites being the most harvested at the onset of the first rains following a dry season [4]. Termites are sold in open markets in various parts of the world including Zambia and Uganda, however, in Kenya, commercialization has been observed in a few counties in the Western region including: Vihiga, Kakamega and Bungoma counties. Furthermore, there has been emerging reports from eastern part of Kenya on inclusion of the termites in the diet and hotel menu. Average income per kg ranges from US$ 3.5-5 for both the hotel operators and the open-air marketers. Commercialization of alate termites is gaining attention,

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although there is anecdotal information on income potential of the alates. The study, therefore, intended to partly fill this knowledge gap by determining the potential of alate termites through survey of the commercialization trends in order to recommend them for income and food resources diversification.

MATERIALS AND METHODS

Study area

The study was undertaken in Luanda and Hamisi sub-counties of Vihiga County, Kenya (**Figure 1**). The higher concentration of activities for termite collection and marketing influenced the selection of the two sub-counties. Hamisi sub-county had the highest number of households of 37,982 in the 2019 household census [12], thus selected to represent the rural households, while Luanda sub-county recorded 26,766, selected as a representation of the peri-urban households. Luanda sub-county forms the largest known termites' commercialization centre, thus was important in obtaining relevant responses. Alate termites are harvested, consumed and sold year-round in these sub-counties [13].

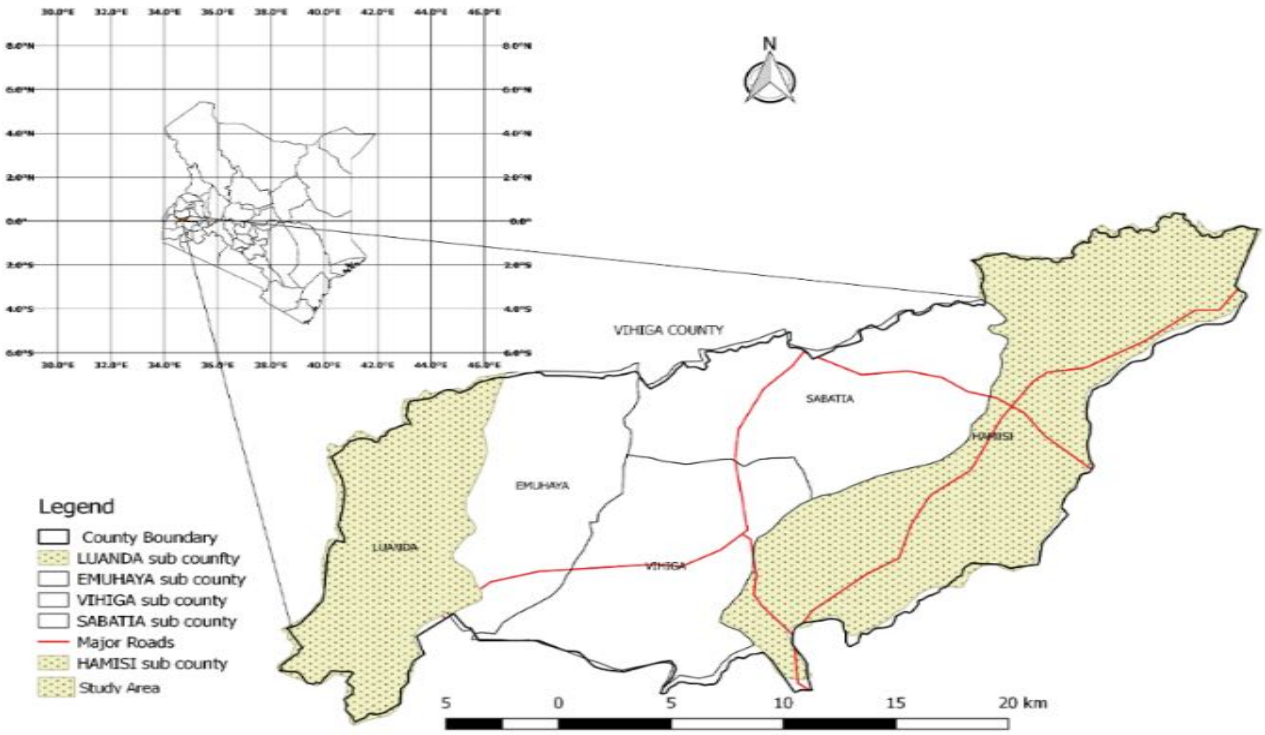

Figure 1: Map of Vihiga County
Source: Anyuor *et al.* [13]

Study design and sampling technique

A cross-sectional survey design was used in this study to describe the potential of alate termite collection and utilization on household food security.

The target population was obtained through multistage sampling procedures [13].
The population sample was obtained as follows:

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

where; n-is the sample size, N -is the population size (64,752 the population of Luanda and Hamisi sub-Counties), e- the level of significance (**Table 1**).

$$n_1 = n * \frac{N_1}{N} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

$$n_2 = n * \frac{N_2}{N} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

Where;
n_1 and n_2 are the sample sizes drawn from the first and second strata (Hamisi and Luanda sub county) respectively whereas; N_1 and N_2 are the corresponding household population sizes of Hamisi and Luanda sub-counties, respectively.

Data collection
Data collection was by the use of semi-structured pretested questionnaire, administered through face-to-face interviews using the online data kit (ODK collect). The application (ODK) was to ensure efficiency, convenience, cost-effectiveness as well as aid in reduction of transcription errors that would be committed during data entry. The questionnaire was organized to cover collection and utilization of alate termites, termite collection and household income and livelihood diversification.

Data Analyses
All the analyses were done using R version 4.0.2 (RCore Team, 2020). Data management was done to come up with a composite variable of the five-point Likert scale which was in turn used further in the analysis. The study sought to assess how termite collection and commercialization contribute to household income for improved livelihoods. Both descriptive and inferential statistics were used to analyze the data. Descriptive statistics inform of frequencies and percentages displayed the extent of commercialization, collection and marketing. Chi square was employed to test the association between commercialization and the respondents' socioeconomic variables: gender, occupation and level of education. Regression analysis was used to assess how termite collection and commercialization contribute to household income for improved livelihoods. Furthermore, Gross Margin Analysis was employed to determine the profit margins and income returns obtained from marketing of the alate termites.

Ethical Considerations
Ethical approval was obtained from Jaramogi Oginga Odinga University of Science and Technology Ethics Review Committee with approval number 7/16/1/20-2 and a research permit granted by National Commission for Science, Technology and Innovation with reference number, NACOSTI/P/21/13050. Access permit was obtained from the local area administration. The respondents were first informed about the purpose of the study and were then asked to participate in the survey if they agreed.

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RESULTS AND DISCUSSION

Collection and marketing of alate termites

A whopping 81 percent of respondents consumed alate termite, as 30 percent and 50 percent of residents participated in alate harvesting and marketing respectively as reported by Anyuor *et al.* [13]. Termites are mostly collected for personal consumption but some are commercialized when there is high supply especially during wet seasons. The demand for termites provides ready market within specific villages and cities. This corresponds with various studies showing that termites are collected and sold in open markets such as in rented kiosks or open air within peri-urban and urban centers in the study area [6]. Marketing is dominated primarily by women, who also sell groceries but specialize in termite sales during peak seasons. Wholesalers buy the alates from local traders or collectors and in turn sell to retailers, who subsequently sell to consumers. The business is concentrated around urban areas, along the roadside or highway vehicle-stopping points where there are networks of distributors, sellers and buyers.

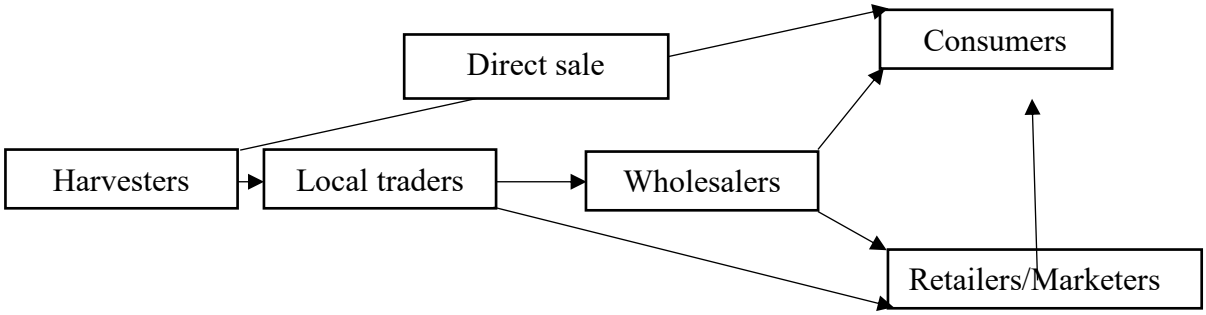

Figure 2: Supply chain of alate termites in Vihiga county
(*Source-own creation*)

The extent of commercialization was assessed by looking at the quantities harvested and sold, relative price, amount of income obtained and household livelihood (Table 2). The respondents interviewed took part in alate termite harvesting, with half of the total harvesters taking part in open alate termite marketing, primarily along the bus stops in Luanda and Hamisi sub-counties. Even though there was no correlation between gender and collection for sale, termite harvesting in this region is dominated by females, 23 (71.8%). Females were depicted to be the most involved in harvesting and open-air marketing of alates. Other marketers (23%), nevertheless, stated that they were not directly involved in harvesting but obtained the alates from harvesters. This corresponds with findings by Netshifhefhe *et al.* [14], which noted that the marketers were not actively involved in harvesting but instead purchased termites from local harvesters.

The analysis revealed that, respondents' choice to participate in marketing was influenced by their educational level and occupation, p=0.026 and p=0.014 respectively. Farmers were the most involved in marketing (62.5%), followed by casual laborers, while educationists were the least involved. This was due to the ease with which most farmers could access the mounds while engaged in other farm activities which allowed them to harvest a greater quantity of alate termites. Thus, they were also

more informed about the alate termite emerging grounds. The majority (64%) of marketers had been in the alate termite business for 3-5 years while others had been in the business for 6-10 (28.1%) years, and some had been in the business for less than 2 years. There was a statistical significance (p=0.0412) indicating there was an influence of individuals' occupation on duration spent in the business with farmers having spent the most time about 3-10 years.

Potential of alate termites as an enterprise

Gross Margin Analysis was used to determine the profitability/potentiality of alate termites as an enterprise in form of gross margin profit from various marketers, in order to assess the benefits and impact of alate termite marketing to household food security system. The Gross Margin analysis (GM) is given by the following equation using the variable costs and receipts.

NR = TR - TC

Where; GP = Net Revenue

TR = Total Revenue (Kshs…)

TC = Total Cost (Kshs…).

The rule of the thumb for Net Revenue is that when Net Revenue is greater than zero it is regarded as a profitable enterprise.

Market- Market Price, quantity sold, distance covered.

Expenses, no labor costs, transportation cost.

NR=TR-TC

TR=average kilograms harvested by the cost per Kg

TC= average distance to the market by the cost of transportation.

That is 51+100/3=50.33Kgs/month

GP=TR (50.33Kgs*Ksh500)-TC (est.10Km*Ksh50)

25,166.7-500

GP =Ksh 24,667 per month

The GP was calculated as a model for other marketers using various modes of transportation (Table 2). The GP remains greater than zero, indicating profitability. Other costs, such as preservation, packaging, and municipal fees are not included. This is because most marketers indicated that the alates are sold in open markets, with the consumer bearing the cost of packaging. This study however, did not place much emphasis on the GP obtained by actors involved in value addition but focused on returns by the local traders. A study in Kimilili sub-county reports the commercialization of the (edible winged) termites and its role as an alternative livelihood source for rural and urban households [6].

Similarly, several researches have been done on the potential of edible insects to contribute to livelihoods, for instance harvesting of the mopane caterpillar *Imbrasia*

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belina (Lepidoptera: Saturniidae) in Southern Africa is an 85 million US$ business, mainly carried out by women [15,16]. The marketing of the edible stinkbug, *Encosternum delegorguei* (Hemiptera: Tessaratomidae) in sub-Saharan African countries mainly benefits women in impoverished rural communities [17]. Edible pupae of a saturniid wild silkworm are commercially reared for sericulture in Madagascar which in turn contributes to poverty alleviation. Likewise, weaver ant larvae and pupae sell for about US$12 per kg in Laos and their sale can account for up to 30% of annual household income in rural Thailand.

Commercialization and livelihood diversification

Sources of livelihood varied among households, as many obtained their livelihood from crop production (50.5%), livestock production (6%), salary (18%) and from alate termite business (9%) and other sources. Trading of alates has thus been ranked as a significant source of livelihood (9%), contributing to diet diversification and income level (100%). Particularly during peak seasons, as indicated by responses from households who acknowledged having attained high food security during alate termite seasons. A chi square association test on increased income level and the respondents' socio-economic characteristics was not statistically significant. However, the analysis on association with sources of livelihood and market supply displayed a strong significance ($p<0.05$) on the level of income obtained. This could be because a number of households earned money by supplying alate termites to the market rather than selling in rural areas where prices were lower.

Furthermore, test of association on collection for sale and improved livelihood had a significant (p=0.0058) impact on diet diversification and income level (Table 4). This is supported by research, on trading of alate termites for income generation at local markets, as barter trade with traditional beer, for crop produce [18]. In absolute terms and when proportional to household income, annual income from alate was adequate for household livelihoods (Table 3). Most respondents confirmed that collection and marketing of alate termites was very useful in cushioning most households during periods immediately before the rainy seasons. This study affirms the responses that the alate termites are consumed as staple rather than snacks, but are one of the few options available for households' adding variety to food consumed [6].

Apart from consumption/diet diversification (81%) and income generation (9%), marketing of alates increases household purchasing power allowing rural households to secure other household needs such as clothing, school fees, and other household necessities to sustain their livelihoods. On average, half of the consumers sun-dried the alates and ground them into powder/flour which is used in baking/making other products such as buns (85), porridge flour (45), muffins (24) and crackers. Several studies reported that the powder can be baked with other ingredients or processed and sold in both local and regional markets [2,19]. Thus, could be explored to encourage rural industrialization in order to employ residents and complete the harvesting and commercialization chain as a supplement to other sources of income [18].

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Constraints to commercialization of Alate termites in Vihiga County

The potential of alate termites and other edible insects has been explored. However, there is scanty information about actors taking part in value addition since most of the retailers sell fresh alate termites that exposes them to risks of perishability and contamination. Additionally, 48 (25.8%) of respondents stated that there was adequate supply of alates in the market. On the other hand, others disagreed, stating that marketers source alates from other counties due to increased demand in Vihiga County. The increased demand led to rise in retail prices hence higher returns for households. This poses threat on the supply side within the county, therefore calling for interventions on how to ensure year-round supply. Nevertheless, the entire edible-insect value chain has not revealed its potential and still requires governance in terms of research, business incubation, and above all, legislation and regulations [20]. Additionally, in trying to use edible insects to address food insecurity, policy makers should note insufficiency especially for seasonal edible insects such as alate termites.

Despite several studies having proven that 500 species of edible insects are consumed in Africa, it is still a paradox especially ensuring year-round supply of the seasonal edible insects [21]. For the continent, the development of suitable and sustainable technologies to increase quantities of insects for use on an industrial scale is a major challenge. Therefore, the best strategies that could be envisaged to sustainably create a viable industry in alate utilization as food includes; maximizing harvesting from the wild in a sustainable manner, developing appropriate post-harvest handling practices and conservation technologies.

Strategies for dealing with the factors impeding Alate termite commercialization

Promoting alate termite commercialization within the study area and beyond was assessed by asking a set of three questions drawn to determine extent of agreement. First was helping marketers to access credit facilities to expand the termite business through venturing into value addition. A Chi square test of association between respondents' education and access to credit was positively significant ($p=0.00017$). As individuals' education levels (secondary and tertiary) rose, so did information on the availability of credit facilities and regulations implying that those marketers would be helped to access credit as a capacity-building intervention to expand their businesses.

Credit sources are mostly classified as either formal, semi-formal or informal credit [22]. Formal is obtained from commercial banks or some credit funds while informal from relatives, individual lenders, and associations. On the other hand, semi-formal sector includes microfinance institution or NGOs, government-supported lending programs that aimed at promotion of exportation as well as processing of alates into finished products which would attract more consumers both regional and local to break the limitations associated with sensory characteristics. The credit sources availability depends on the enterprise an individual is involved in.

Frequent training and creation of awareness by extension staff on sustainable harvesting was significantly ($p<0.05$) correlated with level of education, thus indicating awareness on the need for training. This would enhance maintenance of the micro-ecosystem for continuity in the termite colony. Sustainable harvesting would regulate

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mound destructions to promote habitat properties which contribute to abundance. Providing market links to marketers would also promote commercialization especially of the processed products which would attract higher prices in areas away from the harvesting sites either locally or globally.

Additionally, value addition can be promoted to preserve the alate termites so as to extend their shelf life beyond the harvesting season; this will expand the demand to new and international consumers through increasing the appeal and awareness of the nutritional and economic potentialities.

CONCLUSION

Alate termites have been embraced by several households as a considerably potential source of income. Therefore, they can be used as a vehicle for economic empowerment of local communities through livelihood diversification. Average price paid for the alate termites in the market is US $5 per kilogram. This compares favorably with that of other protein sources like goat meat, which retails at approximately US $3 per kg. The edible insect having been part of the diet for quite some time is considered a delicacy. The trade is dominated by women who purchase the alates from harvesters within Vihiga and neighboring counties. In turn, they sell to retailers who later sell to consumers in the open-air markets or directly to consumers. Likewise, consumers obtain the alates from harvesters. The business is concentrated along the highway vehicle stoppage points within the county where there are networks of distributors, sellers and buyers. However, short shelf life and seasonality are some of the challenges facing the marketers. Therefore, the study recommends the need to venture in value addition and other processing techniques that would ensure increased shelf life to promote the termite business as well as ensure year-round supply.

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Table 1: Distribution of sample per the sub-counties

County	Sub-county	Household population	Total sample	Proportionate samples.
Vihiga	Hamisi	37,982	$n = \frac{64752}{1+64752(0.07)^2} =$ 204	120
	Luanda	26,766		84

Table 2: Key Components of Utility Theory Calculations

Quantity harvested per season @4months (frequency)	Pricing of alates	Average transportation cost/Km	Average distance to the market
1-50Kg (25%)	1 table spoon @sh. 5 250gms @ sh. 30	Motor cycle @ sh. 50	2 – 10 km
51 – 100 kg (75%)	500gms @ sh. 100 1 kg @ sh. 400 - 600 2 kg @sh.800 - 1000	Public service vehicle @ sh. 40 Bicycle @ sh. 30	> 10 km < 1 km

Table 3: Chi Square Model on socio-Economic Status and utilization purposes of alate Termites

Variable	Education			Occupation		
	X^2	p-value	df	X^2	p-value	Df
Availability	36.55	0.0002*	12	25.76	0.011	12
Access	29.21	0.003*	12	-	-	-
Income	32.89	0.004*	15	33.09	0.004	15
Adequacy	26.14	0.010*	12	-	-	-
Health	26.72	0.008*	12	-	-	-
Nutrition	27.42	0.025*	15	29.86	0.012	15

Table 4: Summary of the Estimates of the Regression Parameters

Regression coefficients					**Multicollinearity**	
	B	**Std. Error**	**t-value**	**p-value**	**Tolerance**	**VIF**
Constant	1.035	0.594	1.744	0.093		
Utilization purpose	0.755	0.233	3.242	0.003*	0.462	2.163
Quantity sold per season	-0.478	0.247	-1.933	0.064	0.770	1.299
Income per season	0.301	0.276	1.091	0.285	0.428	2.336

*** Indicates significance at 5% level of significance**

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