Assessment of the Effect of Handling, Processing, and Storage Practices on the Quality of Bee Products from Africa's Most Renewed Bee Village in Tanzania

ABSTRACT

Aim; *the main objective of this study was to evaluate the effect of handling, processing, and storage practices on the quality of selected bee products (honey, bee wax, propolis) from Africa's most renewed bee village in Tanzania.*

Material and methods: *The study implemented a mixed- methods approach. Purposive and random sampling techniques were used in this study to select a total of 106 participants who were taken as a sample from universal populations. Both primary and secondary data were collected through focal group discussion, interviews, and questionnaires. Qualitative and quantitative data were analysed using IBM Statistical Package for Social Sciences (SPSS) Computer Programme version 26, using descriptive and inferential ststistics*

Results; *This study identified significant factors that contribute to the successful production of quality bee and honey products from Kijiji cha Nyuki. Factors that were identified consist of handling, processing, and storage procedures; it was specifically noted that, regulations compliance, application of current technology, ongoing workshop and training, and skilful management and farm workers. The study found those involved in beekeeping and policy implementers do employ several techniques to ascertain the quality of bee and honey products. Beekeepers regularly make use of new equipment such as 20 plastics, knew knife cutting honey jelly, a smoke machine for design for disposing of bees and clothing designed for beekeeping activities. These activities take place during the sun time, the harvested is transported to* factory for processing and packaging. *The results reveled that handling procedure, processing procedure, and storage practices had significant impact on the quality of bee products, it was recognized that intensified agriculture handling procedures had more influence on bee quality compared to other proxy measures such as harvesting methods and pest and predators uses. Also, in processing procedure it was found that straining than boiling, sun heating and pressing. Further, storage procedure such as separate room store, inside house, inside store, and storing tools had effect on the overall quality of bee products.*

Contribution to policy implication; *This study recommends interventions among farmers and beekeepers on the safe use of good hygienic handling, and storage practices. It has contributed to the understanding of how the quality of bee products is assured by adhering to technology, training, and skillful management of bee products. This calls on policymakers to rethink ways of engaging the beekeepers and to have an ongoing discussion with beekeepers and concerned stakeholders about a model that could be used to enhance pesticide regulation in Tanzania.* This study calls for further research that would focus on findings ways for sustaining quality. Technically, farms hardly comply with government regulations, and the government lacks the know-how in terms of influencing beekeepers to stay away from the application of non-approved insecticides which has long-term implications for sustainability.

Key Words: *Quality Bee Products, Handling Procedures, Processing Procedures and Storage Procedures*

1.0 INTRODUCTION

One of commonly known honeybee products is honey that had composition of proteins, free amino acids, vitamin, minerals, water, pollen and wax by estimated 0.2 to 0.3% and carbohydrates (75% of fructose and glucose)

(Luvanda, & Lyimo, 2018; Hungerford 2020; Alavaisha, 2020; Brina et al. 2021).The other bees products such as bee pollen, beeswax, royal jelly, bee venom, bee propolis, and bee brood that produced as natural instinct of honeybees that have vital and unique usage to human being as they contain medical benefits that consumed for centuries Maurya (2020). Bee products such as honey, bee pollen, beeswax, royal jelly, bee venom, bee propolis, and bee brood have significant usage to human being for centuries in every civilization, it has been used for certain purpose like promotion of immunization to several infection diseases and enhancement of health nourishment (Darko, Tabi, Adjaloo, & Borquaye, 2017). Irungu, Suresh, and Torto (2016) described that presence of pollutant such as pesticides in bee products like honey can devaluate its values and constitute potential risk to human health when consumed.

It is noted that bee products can be contaminated into two common means, first through direct contamination that occurs due to handling and substances that used by beekeepers; and second is indirect contamination that occurs due to transportation of unwanted and toxic substances during the collection of pollen, nectar, water, and propolis and transferred to beehives. And one of the toxic substances is high concentration of pesticides that mostly caused by socioeconomic activities like agriculture (Muli, et al., 2018).

Honey is one of the sweet, flavourful natural products produced by bees from nectars or honeydew. It is composed of carbohydrates (75% of fructose and glucose), 0.2-0.3% of proteins, free amino acids, vitamins, minerals, water, pollen, and wax [1;2;3;4]. The composition of honey depends on the plant species visited by the honeybees and the environmental handling and storage conditions [5] Data on the quality of bee products (honey, beeswax, beebread, propolis) due to handling, processing and storage practices in Tanzania is so scanty. Irungu et al. [6] described that the quality of bee products can be affected by two common ways, first through direct contamination that occurs due to handling and substances that are used by beekeepers; and second is indirect contamination that occurs due to the transportation of unwanted and toxic substances during the collection of pollen, nectar, water, and propolis and transferred to beehives. The quality of bee products relies of the formulation of composition during the collection process by honeybees when visiting different plant and flower species, also the surrounding environment and handling process performed by beekeepers and the condition of storage facilities that are used [5].

The demand for honey in globally is high which results in estimated 1.4 million tons of honey produced worldwide as described by the European Commission (2022), Europe is considered one of the leading consumers of honey products as well as one of the leading areas with approximately 226 thousand tonnes produced yearly as indicated in 2019 but the production has been declined in 2020 to 218 thousand tonnes which is equal to 12% of the global honey produced [7]. In Europe, Hungary is the leading producer of honey with 15 to 20% of all honey in the European Union but experienced strong competition from developing countries that export high volumes of honey to the European Union [8]. The other leading producer of honey worldwide are China (22%), the USA and Argentina (6%), and Turkey (5%) which led to global honey production of approximately 1,860,172 tonnes yearly, the leading producing countries of honey globally are China being responsible for 22%-29% of all production, followed by European Union (12%), Turkey (6%), and Argentina (4%) [9].

It has been noted that there is decline of honeybee colonies currently which become a big concern of globally not only for handling pollination activities which is vital for plant and food production but also because the number of colonies are important to the volume of honey which had several significant benefits to human. The quality of bee colonies has been negatively affected by multiple factors such as poor nutrition, pests, diseases, and loss of natural bee habitat, the widespread uses of pesticides in agricultural activities were described as major socioeconomic activity that affects the health of bee colonies [10;6].

The composition and properties of honey are dependent on handling processes, floral origins used by the bees, and the climatic conditions of the area from which honey is harvested. According to [11], nowadays bee products are produced in an environment contaminated by different sources of chemicals. Heavy metals, organophosphates, pesticides, and veterinary medicines are considered to be among the important potential pollutants [12].

The recent sudden decline of honeybee colonies is of global concern not only because of the pollination services they provide in the food production process but also due to honey production among other benefits. While there are multiple variables, including poor nutrition, pests, diseases, and loss of natural bee habitat, negatively affecting bee health, it is becoming increasingly clear that the widespread use of pesticides on crops is a major factor [10];[6]. For example, millions of tons of pesticides are applied annually, but only a small fraction (<1%) effectively reaches the target organisms, and the remainder is deposited either in the soil, atmosphere, or water, contaminating the environment and non-target organisms [13]. In Africa, honey is largely produced in Ethiopia,

with approximately 45,300 tonnes annually, followed by Tanzania which produces about 30,393 tones of honey per annum and, 1,843 tons of beeswax. Other Eastern African countries that have been doing well include Kenya, Uganda, and Rwanda producing about 4000 tonnes for domestic consumption and export to the UAE and Middle Eastern Countries [14]. Honey production in Africa increased from 78,873 tonnes in 1971 to 150,911 tonnes in 2020, with an approximate growth rate of 1.65% annually [15].

Honey production in Tanzania is an extended established economic activity, which contributes to socioeconomic development, and environmental conservation. It is an essential activity for income generation for most communities living nearby forests and woodlands, the more than two million people, account for approximately 99% of the total honey produced in Tanzania, which continues to be below 1% National GDP, being too low compared to the existing potential. Among countries around the world with the highest potential for the production of bee products, Tanzania is one of them, due to the availability of abundant plant species producing nectar and pollen. The country has around 33.5 million hectares of forests and woodlands distributed over the country, with the potential for boosting the beekeeping business. Unreserved forests and woodlands cover almost 20.5 million hectares, with 13 million hectares as forest reserves. Forest plantings that are also ideal for beekeeping cover more than 80,000 hectares of the gazette forest reserves. The 115,500-hectare mangrove forests of mainland Tanzania are also significant as bee feed. From the 30,993 tonnes of honey and 1,843 tonnes of beeswax produced in Tanzania approximately 7% of the products are internally utilized in candle making and batiks whereas approximately 3% is exported [8]. Main buyers of the exported products include Germany, the United Kingdom, Belgium, the USA, Japan, and the Netherlands [16]. Beekeeping has the potential of being conducted in the agricultural area since a lot of bee products may be harvested from crops including sunflower, green beans, coffee, coconut, and sisal [17].

Bees are termed to operate in either inside or outside clean, healthy, and safe environments from which pollen, nectar and water is collected [18;19]. However, bee products are recently produced in a contaminated environment with bacterial, and fungal spores, dust and chemical residues, industrial pollutants, hydrocarbon emissions and naturally occurring toxins found in plants [16]. The handling, collecting, and storing are major factors affecting the bee products, thus a need for the preservation of bees as well as the products for best quality [8]. To preserve bee product's health which is inextricably integrated with human health and preserve the quality of bee by-products, especially honey, requires regular monitoring using rigorous analytical methods to confirm product quality [15].

Unfortunately, only a few researches have been conducted to display pesticide residues in other hive products such as bee pollen, bee venom, royal jelly, bee wax, bee bread, and propolis, whereby, most of the research concentrated on honey since that is the readily available and mostly consumed bee product. These products are recently used as medical products hence the potential of bioaccumulation in the human body [20]. Therefore, this research was designed to determine the pesticide contamination in bee products from selected honey-producing areas (Singida) in Tanzania. Data on the contamination of bee products (honey, beeswax, beebread, propolis) due to pesticides in Tanzania is so scanty. Due to the frequent use of pesticides on cultivated and forest crops close to beehive farms, and the development, production, and use of various pesticides with new designs together with the associated harmful effects on human health, it is important to assess their levels in the bee products. Therefore, the study was focused on determining the effect of handling, processing, and storage practices on the quality of selected bee products (honey, bee wax, propolis) from among the selected farms from honey-producing regions in Tanzania, the Singida region chosen as a case study. Specifically, by assessing harvesting techniques, storage containers, and additives.

2. Empirical Literature Review

Alemu, et al [21] conducted the study to assess postharvest handling of honey and other bee products and detect opportunities ad effects on the quality of honey production in Ethiopia, the study selected purposively two district officers dealing with bee products and four peasant association leaders were randomly selected. The outcome indicated that the apiculture subsector was affected by the indigenous beekeepers' skills and knowledge on handling, and storage facilities used such as earthen pots, gourds, and animal skins playing significant on the quality of honey harvested. The study recommended the conservation of natural resources, and the provision of high qualities resources and facilities would improve the apicultural sector in Ethiopia.

Kugonza and Nabakabya, [22] investigated the factors that have contributed to affect the quality of honey in Uganda, the study surveyed an estimated 120 beekeeping households and sampled honey from several

supermarkets, stall markets, and hawkers and assessed using Diastase Number (DN), Hydroxymethyl furfural (HMF), Moisture Content (MC), and Free Acidity (FA). The results found that most of the households were harvesting honey using baskets and grass hives which have a positive contribution to lowering the quality of honey from local households in Kampala, also it was revealed that pressing, straining, and boiling were common processing practices of honey which compromise the quality of honey as well as harvesting immature honey, poor extraction procedure, lack of proper equipment, bad weather also contributed on impacting the quality of bee's products in Uganda. The study recommended training on proper honey harvesting and extension on handling, processing, and storing bee products to preserve their quality should be emphasized.

Darko, et al [23] investigate improper use of pesticides causes accumulation of residues in foods, which decreases the safety and quality of food products and ultimately results in serious health problems. The results indicated that acute toxicity explains how poisonous a pesticide is to a human, animal, or plant after a single short-term exposure. The effects of acute toxicity appear quickly, or within 24h of exposure, acute toxicity can be measured as acute oral toxicity, dermal toxicity, and inhalation toxicity.

Bett [24] conducted the study on factors that influence the quality of honey in Kenya, the study used a descriptive research design for the collection of data using a questionnaire and interviews from a sample size of 90 respondents selected through simple random sampling techniques and analyzed by qualitative means using table and percentages. The results found indicated that smokers and protective clothes were the common practices used for harvesting honey which have a diverse effect on both bees and quality of honey production, the study recommended that the government to design proper forums that would promote farmer's awareness on better harvesting techniques with few effects on the health of bees and quality of honey.

2.1 Bee Products Processing

These are the processing techniques and procedures adopted for harvesting, extraction, purification, and separation of bee products from its raw nature with consideration of maintaining minimum effects on the health of honeybees [25]. The procedure for each product is described in detail below paragraphs;

2.1.1 Honey processing

Honey processing is not a straightforward sequential chain of activities, although the average consumer might think so at first glance. It should be emphasized that each processing stage, from the initial extraction to the packaging of the finished food product, is a solution to unique challenges relating to the physicochemical characteristics of various kinds of honey [26].

Uncapping is the first stage in obtaining honey. The wax caps from the honeycomb cells must be removed. This is done by hand in small processors while uncapping machines are used by large processors to scrape the wax caps off honeycomb cells one frame at a time in a fully automated operation [26]. Using an extractor, the honey is extracted from the cells. Typically, the frames are placed in a centrifuge, which rotates the frames and forces the honey out of the comb. The honey is spun to the extractor's sides before draining out the bottom into a collection receptacle. To extract the leftover honey, use a screw press to press the remaining wax.

Filtering raw honey can be difficult due to its viscous and sticky nature. Prior to filtering, honey is frequently cooked to 66°–77°C to reduce viscosity. Pasteurization of honey necessitates temperatures of 72°C or higher. The heating method also reduces moisture content, delays crystallization, and kills yeast cells, extending the shelf life of the product. Furthermore, heating the honey causes it to turn a darker brown color. Heating can be done in tanks or above the product with an infrared heater or heat lamp.

Membrane filters are the most prevalent type of filter. Depending on the pore size and distribution of the membrane, certain substances flow through and others remain behind. Using metallic or nylon screens, macro-filtration is used for gross filtering (10–1,000 µm) to remove bubbles, dust, insect bits, and crystals. The honey is categorized as raw honey if this technique is utilized and no heat is applied. Yeast cells, coal dust, and certain microorganisms are also removed using microfiltration (0.1–10 µm). Ultrafiltration (0.001–0.1 µm) is a method that is occasionally used to produce a finished product that is no longer classed as honey in the United States. The process of ultrafiltration entails adding water and filtering it under high pressure.

Ultrasound can be used to nonthermally treat honey which involves temperatures around 35°C and times less than 30 seconds. Honey can be processed through controlled crystallization. Creamed honey contains a large number of small crystals, which prevent the formation of large crystals; it has a smooth, spreadable consistency.

According to the study by [27] during the first sixth months of storage, glucose and fructose levels dropped significantly (P <0.05). It has been noted that the sugar spectrum of ripened honey does not remain constant throughout time, but rather changes.

2.1.2 Propolis processing

Most industrializes of propolis are primarily based totally from the number of liquid extracts. The uncooked prospolis is hardly ever acceptable for direct inclusion in the very last products. Similarly, for large public or small scale raw propolis is normally handled with a solvent, and best the ensuing extract is used. The typically used is ethanol. The choice of solvent relies upon the final use of the extract and technical feasibility. Most active elements appear to be soluble in propylene glycol and ethanol, whereas fewer elements are soluble in water.

Some manufacturers boil a mixture of alcohol and propolis for 8 hours to dissolve all the resin. If propolis contains wax, most of it must be melted by heating. However, for high-quality products, avoid heating. After 1-2 weeks, the liquid is filtered with a clean, very fine cloth or paper filter, which can be folded into several layers to enhance its effect. A second filtration may be beneficial and better results will be obtained if the extract can be cooled to less than 4^0 C for several hours or a day before filtration, but does not freeze. The filter must also be refrigerated before use. The rest of the initial filtration can be washed again or soaked in alcohol. The filtrate should be a clear liquid, particle-free, dark brown, or slightly reddish in color. It should be stored in a clean, dark, and airtight bottle. If dark-colored bottles are not available, they should be stored in a cool, dark place or wrapped in cloth, paper, or straw to block light.

2.1.1.3 Bee wax processing

During honey extraction, wax is usually removed from the capping resulting to high-quality, light-colored wax. Different qualities of wax can be produced by separating new white honeycombs from darker ones. Since whole combs are harvested and crushed or pressed, the proportion of wax per kilogram of honey (10–15%) will be much higher than with frame hive beekeeping, where the yield is only 1–2%.

To produce high-quality wax, melting honeycombs is the preferred method. This can be achieved by boiling the combs in water in stainless steel containers before separating the pure yellow wax from the comb residue. Cooled and dried wax should be stored in containers made of glass, plastic, or stainless steel to avoid color changes due to contamination by metals [26].

2.1.2 Quality Parameter of Honey Products

The composition and properties of bee products are dependent on handling processes, floral origins used by the bees, and the climatic conditions of the area from which honey is harvested. According to [11], nowadays bee products are produced in an environment contaminated by different sources of chemicals. Heavy metals, organophosphates, pesticides, and veterinary substances are considered to be among the important potential pollutants.

2.2 Theoretical Literature Review

2.2.1 Theory of Planned Behaviour (TPB)

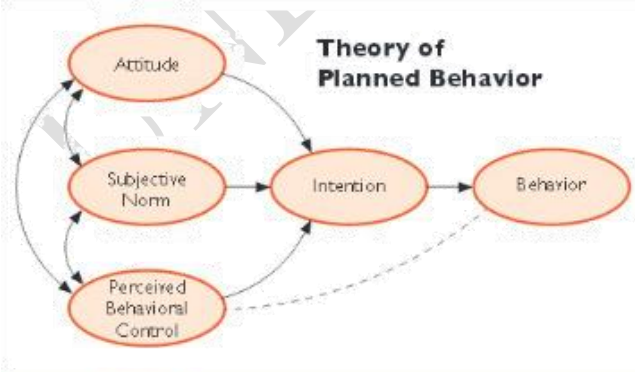

Figure 1; Theory of Planned Behavior

Sourced [29]

The theory of planned behavior was introduced in 1980s to predict individual decision-making toward the presence of certain scenario [28]. The theory argued that human action and behavior depend on individual intention and control ability that are influenced by sociocultural factors and the external environment. See figure 1

In relation to this study, the theory of planned behavior has been utilized to explain the relationship of the individual to use of pesticides in the agricultural activities intentionally to increase food production without considering the impact on the environment, it has been noted that 20% of sickness in Australian has been contributed by the food handling behavior [30].

The behavior beliefs of farmers on the uses of pesticides to boost the fertility of land have caused environmental contamination which results in bees contamination since most of the resources required by honey bees are found on plants and crops, first through direct contamination that occurs due to handling and substances that used by beekeepers; and second is indirect contamination that occurs due to transportation of unwanted and toxic substances during the collection of pollen, nectar, water, and propolis and transferred to beehives; first through direct contamination that occurs due to handling and substances that used by beekeepers; and second is indirect contamination that occurs due to transportation of unwanted and toxic substances during the collection of pollen, nectar, water, and propolis and transferred to beehives [7]. Therefore, the attitude and perceived behavior of individuals have a direct contribution on the intention of using pesticides that results in the contamination of bee products

The theory of planned behavior has been criticized based on the argument that the theory ignored the lack of resources and opportunities for the household to take the decision of using pesticides can be influenced by more factors such as environment factors and economic factors than decision-making of an individual, also the theory fail to describe the timeframe of human intension and control action ability of the individual. But with those limitations, the planned behavior theory (PBT) is more accurately have been utilized in determining pesticide contamination in bee products from honey-producing areas.

3.0 RESEARCH METHODOLOGY

This study implemented a paradigm that concerns the use of quantitative and qualitative approach; the approaches were chosen since they provide an accurate and valid reality on determining the effect of handling, processing, and storage practices on the quality of selected bee products (honey, bee wax, propolis). The descriptive research design was adopted to describe the researcg scenario and situation to find answers to research questions.

The study conducted from the beeproducts producing ares areas in Tanzania, Kijiji cha Nyuki Co. Ltd, located in Singida region. The areas of the study were selected based on the growing bees farming activities as major Agroecological zones in Tanzania in terms of bee production. Kijiji cha Nyuki is one of the major leading bee farming in Africa and a leader in the use of advanced technology and bee farming practices. It owns the bee farm covering 40,000 acres with total of 45,000 beehives. The selected apiaries spread apart (<10m from each other).

3.1 Study Population

The study population comprised Kijiji cha Nyuki bee farm workers, beekeepers, farmers, agricultural and forest officers, and honey users who provided the relevant information on the quality of honey consumed. Kijiji cha Nyuki Co. Ltd contains 23.000 apiaries, whereby approximately 75% of the apiaries are located at Kijiji Cha Nyuki and the remaining are located at **Iginasoni** Ikungi District about 80 km from Singida Municipality.

3.2 Sample Size

Slovene's formula in Equation (i) was used to compute an appropriate sample of the human subject for the study, which is optimal. The population odf Singida as of 2023 is 57,904 The Slovene formula is given by:

$$n = \frac{z^2.N.\sigma^2}{(N-1)\ell^2 + z^2.\sigma^2}$$ Equation----------Eq.1

Where:

$\ell =$ Acceptance error (precision) =5%

$z =$ As per the table of area under normal curve for the given confidence level of 95%= 1.96

$\sigma =$ Standard deviation of population=2

The formulae revieled 95.88262 sample, however, the researcher added 10% calculated sampe amounting to 9.5 so as to eliminate errors caused by missing of major questions and making 103.5 ≈ 104.
Therefore, total was 104 (one hundred and four) respondents. Also, the issues of gender were highly regarded**.** The sample size composition is indicated in the Table 1.

Table 1; Sampling Composition

Participant	Male	Female	Total
Agriculture officers	1	1	2
Forest Officer	1	1	2
Farmers	27	25	52
Consumers (Users)	26	26	52
Beekeeper (Bibinyuki)	1	-	1
Total	**55**	**54**	**109**

3.3 Data collection methods

In this study, multiple methods in data collection including physical observation and survey, interviews and questionnaires were be employed.

3.3.1 Physical Observations and Survey

This was helpfulhelped to identify the vulnerable areas of beekeeping, and farming activities which are located nearby the selected cases. The survey and observation was utilized to assist in providing a clear picture that is on overview of the area and the possibility of the bee-keeping infrastructure to be impacted by the agricultural pesticide. A preliminary survey was helpful to familiarize with the study area, establish contact with beekeepers and test the questionnaire and instruments to be used in the actual study which was conducted in the Itigi area.

3.3.2 Questionnaires

Questionnaires were administered to obtain data and information related to beekeeping, farming activities, and where bee products from Kijiji Cha Nyuki C. Ltd. The questionnaires were prepared with both open-ended and closed questions were used in this study with a clear question sequence, formulation and wording, hence collection after being filled by the respondents for data analysis. The information to be collected includes; common type and the number of pesticides used by farmers, distance from farms and apiaries as well as the handling, processing, and storage practices by beekeepers (harvesting techniques, storage containers, additives used), A total number of 4 questionnaires were administered to both district and regional agricultural and forest officers.

3.4 Data Analysis

The collected qualitatively was analyzed using content analysis while quantitative data was descriptively and inferentially tested. Thus, regression analysis (multiple linear regression model) used to test statistical significance

estimates of the effects of handling, processing, and storage procedures on bee product quality. The level of significance for the interaction effect between dependent and independent variables was tested using scientific procedures in ANOVA dialogue using F-test. Before multiple regression, the diagnostics test for multicollinearity, normality, linearity, and homoscedasticity of residuals assumptions was to shed. The following model was used:

$QBP = \beta_0 + \beta_1 HP + \beta_2 PP + \beta_3 SP + \ldots + €$--------*Eq.2*

QBP= Quality of Bee Products

HP=Handling Procedures

PP=Processing Procedures

SP=Storage procedures

B_{1---n}*= Slope Coefficients for a specific independent variable*

B0= Constant

€= Error Term

4.0 RESULTS AND DISCUSSION

The section presents the findings that respond to the main research objective. The findings draw on data that was obtained from survey questionnaires, key informant interviews, and observation. The actual sample size of the study was 106 respondents. Singida is among the region that has many beekeeping farms, and many residents from the area have access to and are involved in honey production businesses. As such, this chapter presents data in regard to the effect of handling, processing, and storage practices on the quality of selected bee products (honey, bee wax, propolis) from among the selected farms. Before proceeding with any analytical procedures, the study conducted validity and reliability test of the research instruments.

4.1 Validity and Reliability Statistics

4.1.1 Reliability Statistics

The internal consistency of the measuring instrument was done using Cronbach's Alfa test. According to [31] reliability refers to the consistency and accuracy of the research findings. He argued that the reliability of a research instrument concerns the extent to which the instrument yields the same or consistent results on repeated trials. Cronbach's Alfa measures the precision, repeatability, and trustworthiness of the study. It is expressed as alpha = Np/ [1+p (N-1)] Where N equals the number of items and p equals the mean interitem correlation. It is typically varying between 0 and 1, where 0 indicates no relationship among the items on a given scale, and 1 indicates absolute internal consistency [32].

Alpha values above 0.7 are generally considered acceptable and satisfactory, above 0.8 and are usually considered very good, and above 0.9 are considered to reflect exceptional internal consistency [32]. In the social sciences, the acceptable range of alpha values is from 0.7 to 0.8 [31]. Table 2 indicates that, the Crobanch's Alfa for this study tool is 0.94 based on standardized items, which is an acceptable rate of consistency of the measuring instrument. Therefore, the study data was good for further procedures.

Table 2; Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.937	.941	18

Consequently, the study adopted Analysis of Variance (ANOVA) with Tukey's Test for non-additivity that detect the existence of the relationship of factors in the study and hoteling's T-squire Test to measure the significance of internal consistency in the analysis of outcome from the study. Table 3 summarized the results, it indicates that the ANOVA test had P-Values (0.000) of both between people within people and between items within an item; which is very small less than 0.05 indicating the significance internal consistency of the tool at 95 confidence intervals. Therefore, the data collected was statistically significant for further analysis procedures and interpretation.

Table 3; ANOVA with Tukey's Test for Nonadditivity

			Sum of Squares	df	Mean Square	F	Sig
Between People			994.707	105	9.473		
Within People	Between Items		67.132	17	3.949	6.576	.000
	Residual	Nonadditivity	14.858[a]	1	14.858	25.074	.000
		Balance	1057.103	1784	.593		
		Total	1071.961	1785	.601		
	Total		1139.093	1802	.632		
Total			2133.800	1907	1.119		

Grand Mean = 3.8379

a. Tukey's estimate of power to which observations must be raised to achieve additivity = 3.501.

Another reliability measurement employed by the study were the Intraclass Correlation Coefficient (ICC) which describe the reliability of information organized in the group within the study [33]. Table 4 shows the result of ICC in two-way effects have a significant level that less than P-values of 0.05 Which is 0.000, this indicated that the ICC have statistically significant with 95% confidence intervals.

Table 4; Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.451[a]	.382	.529	15.775	105	1785	.000
Average Measures	.937[c]	.918	.953	15.775	105	1785	.000

4.1.2 Validity Statistics

According to [34], validity is the accuracy of measurement of which the independent to dependent variable is to be of truthful for the results. If the research was high in validity that means it was to produce results that correspond to real properties, characteristics, and variations in the physical or social world [35]

In order to ensure validity and reliability, sample adequacy was tested in explanatory factor analysis whereby the **Kaiser-Meyer-Olkin (KMO**) is used to examine sample adequacy.

For the **KMO** statistics, Kaiser (1974) recommends a bare minimum of 0.5 and that values between 0.5 and 0.7 are mediocre, values between 0.7 and 0.8 are good, values between 0.8 and 0.9 are great and values above 0.9 are superb. Table 5 Indicates that the KMO measure of sampling adequacy was 0.79 which is good for further process of analysis.

Table 5; KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.786
Bartlett's Test of Sphericity	Approx. Chi-Square	150.782
	Df	6
	Sig.	.000

4.2 Demographic Characteristics of the Respondents

This section presents respondents' characteristics such as their categories, gender, education qualifications, and age pattern of the school committee members as presented in Table 6

Table 6; Frequency and percentage distribution of respondents by category

	Respondents	Frequency	%
Gender	Female	52	49
	Male	54	51
Age	18-30	10	9
	31-50	67	66
	51-60	29	25
Education level	None	7	5
	Primary	67	65
	Secondary	26	25
	University	6	5

The variation of respondents by gender, whereby male participants n=54 of the respondents, and n=52 respondents were female. The age groups of respondents; the findings reveal n=67 of respondents were aged between 31-50 years of age. This suggests that most of the respondents were aged, followed by n=29 of the respondents who were between 51-60 years of age. Surprisingly, the study uncovered the youth living in the area aren't that much involved in beekeeping activities as compared to the adult community. For example, only n=10 of respondents were aged between 18-30 years old.

As shown in table 6, the majority of respondents n=67 only attended primary school, and n=26 of respondents attended both primary and high schools. In addition, n=6 participants including a beekeeper, agriculture district officers and forest officers stated that they hold a university degree. This study also identified n=7 of respondents never been to school. This is an indication that the majority of individuals involved in beekeeping activities within Kijiji cha Nyuki and the surrounding can read and write which supposes that beekeepers can keep up with regulations if they receive the necessary training.

4.3 Evaluate the effect of handling, processing, and storage practices on the quality of bee products

To investigate this objective the study made use of informants' interviews and questionnaires. The interviews participants consisted of beekeepers (1), district agriculture officers (1), and forest officers (2), while 106 respondents were distributed with questionnaires randomly. Regression analysis was done for quantitative data as well as content analysis for qualitative data

4.3.1 Diagnostic test

To answer the study objectives multiple linear regression (MLR) was conducted by observing all its assumptions (OLS assumptions) such as normality, linearity, heteroskedasticity, and multicollinearity.

4.3.1.1 Normality

Normal testing is an assumption of the regression model that impacts the validity of all tests (i.e. p-test, t-test, and F-test). It shows whether the residuals are normally distributed. This implied that the assumption of normality was well-founded.

The line representing the actual data distribution closely follows the diagonal in the normal Q-Q plot. In Figure 2 the results of the normality test of the independent and independent variables indicated skewness; which suggests normal distribution [37]. [38], averred that in the Q-Q plot, or the normal probability plot, the observed

value for each score is plotted against the expected value from the normal distribution, where a reasonable straight line indicates normal distribution.

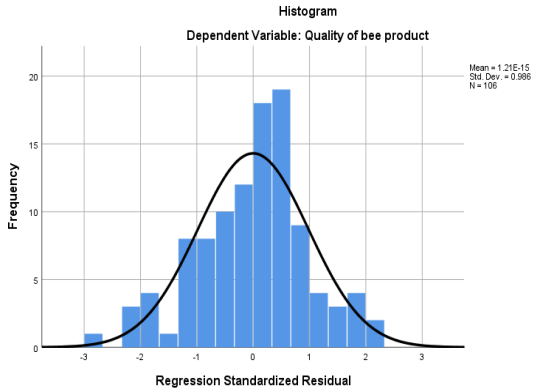

Figure 2; Normality Test

4.3.1.2 Linearity

Figure 3 indicates the tested linearity assumption of data collected through the inspection of bivariate scatter plots, shows no serious violation of linearity, and the scatter plots for the argued component plus residuals were linear because all point variables linearly follow the diagonal regression line. Hair and Sarstedt [36], argued that the linearity of data is often assumed for variables in multivariate analysis and if left unattended, non-linear data can seriously undermine any statistical inference.

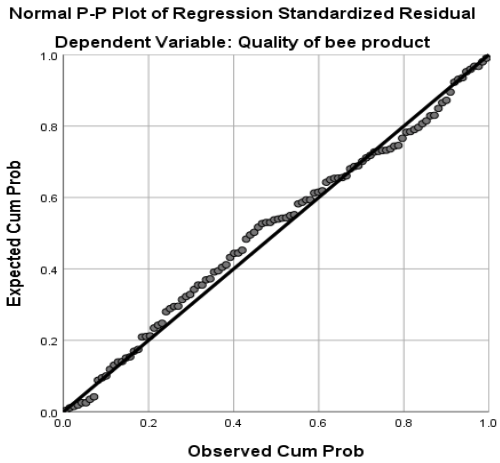

Figure 3; Linearity Test

4.3.1.3. Heteroskedasticity

This assumption states that the variances of error terms are similar across the values of the independent variables. A plot of standardized residuals (Scatter Plots) versus the predicted values has to show whether points are equally distributed rectangular across all variables influencing the quality of bee products. An important assumption in testing homoscedasticity is that the variance in the residuals has to be heteroskedasticity and homoscedastic or constant. The scatter plots (Figures 4, 5, and 6.) are distributed across the rectangle. Therefore, the overall, results suggest that homoscedasticity was not violated for both criterion variables [34].

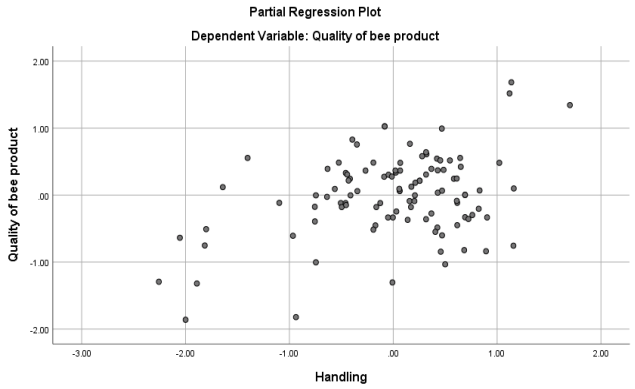

Figure 4; Heteroskedasticity for Handling Procedures

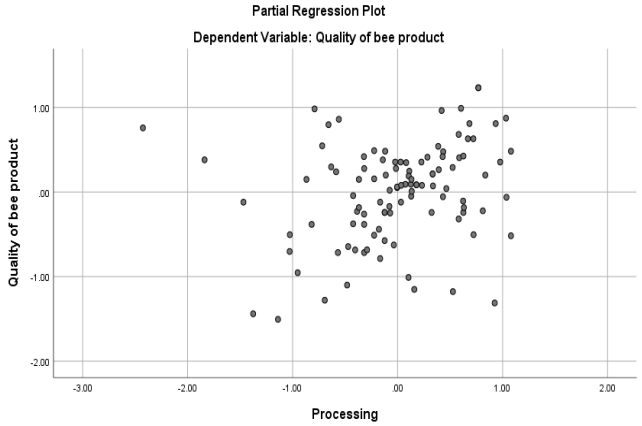

Figure 5; Heteroskedasticity for Processing Procedures

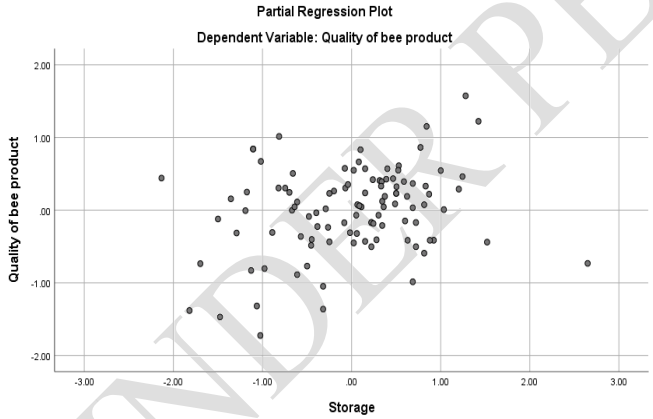

Figure 6; Heteroskedasticity for Storage Procedures

4.3.1.4 Multicollinearity

Multicollinearity results from circumstances where two or several variables are so highly correlated in such a way, they both essentially represent the same underlying construct, that is; what appear to be separate variables measure similar constructs [37]. Table 7 indicates that the variance inflation factor (VIF) had values less than 5 and Tolerant values (1/VIF) are more than 0.2 indicating that there is no problem of multicollinearity among the independent variables. The authors posit that the VIF values greater than 5 and Tolerant values less than 0.2 indicates that there was no multicollinearity among the independent variable included in the model [39].

Table 7; Multicollinearity Test

Model		Collinearity Statistics	
		Tolerance	VIF
1	Handling	.712	1.405
	Processing	.552	1.811
	Storage	.620	1.613

a. Dependent Variable: Quality of bee product

4.4 Multiple Linear Regression Results

Based on this study's objectives, the quality of bee products was the dependent variable while handling, processing, and storage procedures were the independent variables. In order to answer the objectives of this study, three attributes were measured to determine how they influence the quality of bee products. The study considers the significant value less or equal to 0.05 as significant and above 0.05 as insignificant. This means sig- a value above 0.05 has a low probability of explaining the relationship as compared to sig- value equal or below 0.05 which is equal to 95% confidence interval. Also, the R. square portrayed that it could explain the dependent variable by 49.1%. Below is table that shows the significant values and the beta coefficient.

Furthermore, the Analysis of Variance (ANOVA) using regression residuals indicated the significance fit of the model because its P-Value was 0.000 very smaller than 0.05 significance level. Therefore, handling, processing, and storage procedures significantly tell the quality of bee products; *See Table 8*

The regression results reveal the relationship between independent variables were handling, processing, and storage procedures as independent variables and the dependent variable was the quality of bee products; Each slop coefficient (***β)*** is a partial regression coefficient and measures the change in estimated value for a unit change in the value of a given independent variable, while other things remain constant.

QBP = 0.726 + 0.222PEU + 0.083QE + 0.352SI + …….. + € ----------Eq.2

Table 8; Multiple Linear Regression Results Showing Influence of HP, PP and SP on QBP

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.177	.295		3.993	.000
	Handling Procedures (HP)	.312	.074	.352	4.198	.000
	Processing Procedures (PP)	.235	.088	.254	2.675	.009
	Storage Procedures (SP)	.191	.069	.247	2.750	.007
R		.701				
R-Square		.491	F-Change=.000			
ANOVA F-Test		F=32.784	P-Value=.000			

Therefore, based on Table 8 a unit change (say increase) in HP, PP, and SP will lead to a significant statistical change (increase) in quality of bee products (QBP) by 0.312, 0.235, and 0.191 respectively. It has been reported from the participants own perspectives and lived experiences of the investigated phenomena. For example, one of the beekeepers states

> *We apply several techniques to ascertain we maintain the quality of the bee. To ensure this is achieved we use new equipment such as 20 plastics, knew knife cutting honey jelly, a smoke machine for design for disposing of bees and clothing designed for beekeeping activities. The activities take place during the day, the harvested is transported to the factory for processing and packaging - (Respondent 3).*

Respondent (3) opinion was echoed in an interview with respondent (4) who spoke in length about the process involved in harvesting, storage, and transporting of bee and honey products. Respondents (4) noted that:

The product is then packaged in plastic with a volume between one to 20 liters. Honey that is ready for sale is stored in dry, cool, and clean room, and it is not exposed to moisture to ensure that honey is not exposed to unwanted light and air which can affect its quality - (Respondent 4).

The quotes discussed above demonstrate the steps that beekeepers and farmworkers take to account to ascertain bee and honey products produced in Kijiji cha Nyuki is clean and does meet international bee and honey product standards. Participants opinionated that they always apply all necessary steps stipulated in regulations guiding the use of pesticides in Tanzania as per Pesticide Control Regulations 1984 which regulate bee and honey production practices. All participants agreed that beekeepers from the investigated areas continue to comply with the practice of beekeeping as noted in National Environmental Management Act No. 20, Industrial and Consumer Chemicals (Management and Control) Act No. 3, and Occupational Health and Safety Act No. 5. Based on these findings, and the findings from quantitative analysis discussed in objective (3) and (4) reveal some level of correlation between the two methods implying that current level of insecticides used during the seed planting time, harvesting and processing period is within the recommended practices hence there is no any negative effect that was identified. The results show the application of workshops and training as noted by participant (3), and participant (5), and informative community meetings can be relied upon and may be adopted by other concerned authorities. The responses discussed above are further cemented by the participants from survey questionnaires discussed in table 4 and table 5.

5.0 CONCLUSION

Based on the discussion above, the study identified significant factors that contribute to the quality bee and honey products from Kijiji cha Nyuki that consist of handling procedure including harvesting methods, intensified agriculture handling procedures, pests and predators use, and boiling; also processing procedure such as boiling, sun heating, pressing, straining; and storage procedures that includes inside house, inside store, separate room store, and storing tools. Also, it was discussed that in handling and processing procedure, beekeepers regularly make use of new equipment such as 20 plastics, knew knife for cutting honey jelly, a smoke machine for design for disposing bees and clothing design for beekeeping activities. These activities take place during the sun time, the harvested is transported to factory for processing and packaging. The products are packaged in plastic with the volume between 1 to 20 litres. Before selling, the products are stored in dry place.

The findings reveal that beekeepers are aware of local and international market demands; therefore, this investigation concludes that bee and honey products produced in Kijiji cha Nyuki is clean and does meet international bee and honey product standards. This study calls for further research that would focus on findings ways for sustaining quality and investigate beekeeping facilities and handling process on a national level by assessing the quality of bee and honey products produced in various part of the country to determine the level of contamination, and to learn best practices.

This study calls for further research that would focus on findings ways for sustaining quality. Technically, farms hardly comply with government regulations, and government lacks the know-how in terms of influencing beekeepers to stay away from the application of non-approved insecticides which has long-term implications for sustainability. Finally, the future study can investigate beekeeping facilities and handling processes on a national level by assessing the quality of bee and honey products produced in various parts of the country to determine the level of contamination and to learn best practices. The findings spanning from a wide farming community could help policymakers, consumers, beekeepers, and academics to learn the causality. The findings also can necessitate the formation of relevant pesticides policy that speaks to the needs of all concerned actors.

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