INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 21, No. 6, p. 18-25, 2022
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Influence of extraction techniques on consumer acceptability of bee brood (*Apis mellifera*) as an alternative source of protein for improved food security

Kenneth Otieno Owuor*[1], Prof. Christopher Gor[2], Dr. Mary A. Orinda[3]

[1]*Jaramogi Oginga Odinga University of Science and Technology, Kenya*

[1,2]*Department of Agricultural Economics & Agribusiness Management School of Agricultural and Food Sciences, Jaramogi Oginga Odinga University of Science and Technology, Kenya*

Article published on December 03, 2022

Key words: Extraction techniques, Acceptability, Food security

Abstract

Bee keeping improves livelihoods of rural communities due to its low capital requirement and low technical knowhow. Currently, bee brood is removed by beekeepers as part of a strategy to lower the population of the destructive mite (*Varroa destructor*) which is disposed of to keep the hive healthy and avoid colony collapse. The aim was to investigate influence of extraction techniques on consumer acceptability of bee brood *(Apis mellifera)* as an alternative source of protein. The Theory of Planned behavior of planning that predicts deliberate behavior was used. The target population was 2,415 with sample size of 343 respondents. Stratified and simple random sampling were adopted. The study area included five riparian counties along Lake Victoria namely: Busia, Homabay, Migori, Kisumu and Siaya. Descriptive research design was adopted using questionnaires, Key Informant Interviews and Focus Group Discussions. Data was analyzed and presented using thematic analysis, inferential and descriptive statistics with the aid of SPSS software. Mean and standard deviation were used to measure central tendency and dispersion respectively, while inferential statistics included multiple regression and correlation analysis. The results for Pearson correlation indicated that extraction techniques (r=0.311, p=0.000) had significant statistical influence on acceptability of bee brood as food and that squeeze-method (M=3.63,S.D.=1.0,P>0.05) and warming (M=3.64,SD=0.467,P>0.05) were sustainable brood extraction methods. Moreover, agricultural extension officers should sensitize actors on the consumption of bee brood and its products. In the interest of biosecurity, it was recommended that beekeepers disinfect beekeeping equipment that comes in contact with bees to increase brood productivity.

***Corresponding Author:** Kenneth Otieno Owuor ✉ kenowuor52@yahoo.com

Introduction

Although the increase of world population growth is stagnating, the world population itself is still growing quickly. In the year 2050, the world population is expected to count a staggering 9 billion people. In order to feed all of them, food production will need to almost double (Van Huis, Van Itterbeeck, Klunder, Mertens, Halloran, Muir, & Vantomme, 2013). Entomophagy (the concept of eating insects) is gaining wider attention and acceptance globally due to a number of studies and innovative start-ups that use insects and insect-based ingredients (FAO, 2013). The potential of insects for food and feed has gained global attention in the past few years and with good reasons: many species require fewer resources to rear, have a lower environmental impact than domesticated livestock (Oonincx *et al*., 2010), have high nutritional levels (Rumpold & Schlüter, 2013), and high gastronomic value all over the world. Approximately 2,000 species are eaten as food (Van Huis *et al.,* 2013). By no means are insects a "new" food to humanity and their potential for improving global food systems by diversifying our food supplies is considerably high. Entomophagy, could be a possible solution for developing economies, Kenya included (Alemu *et al.,* 2017a). Edible insects are nutritious, always available and have a lesser ecological footprint (FAO, 2013).

Bees (Apis mellifera) is native to Africa, most of Europe, and the Middle East, but has been introduced by humans to the Western Hemisphere, Australia, and the rest of the world. The species has been recently introduced in commercial scale in the islands of South-East Asia (Koeniger, *et al.,* 2010; Engel, 2012). The western honey bee (*Apis mellifera*) is the most common of the 7–12 species of honey bees all over the world (Engel, 2012). It is a hymenoptera species of insect belonging to the Apidae family. The genus name *Apis* is latin for "bee" and *mellifera* is Latin for "honey-bearing", referring to the species' production of honey (Golag, 2010*)*. It is a promising edible resource consumed in many cultures across the globe (Annette, 2015). Within the species there are a number of races of bees which have their own particular characteristics. These are: *Apis mellifera scutellata, Apis mellifera monticola, Apis mellifera yeminitica (nubica)* and *Apis mellifera littorea* (Carroll & Kinsella, 2013).

Tabinda *et al.* (2013) defines Beekeeping or Apiculture as "the preservation of honey bee colonies to get pure honey and other products and helps in pollination by human beings". In fact, beekeepers can get huge returns, as apiary production only requires a small piece of land for which hives are to be placed. Therefore, the practice provides livelihood opportunities for women and landless people (CTA Spore, 2017). *Apis mellifera* bee species has immense ecological and economic advantages over other species like their high capacity to collect honey as compared to other species of bees, live for a comparative longer time in their beehive, a very prolific pollinator which ensures that the quantity and quality of the crops improves and therefore improves the overall honey and brood production as well (Breed & Moore, 2016). Bees are well known for their products that have a lot of economic value which include honey, bees wax, propolis, royal jelly and bee brood (FAO, 2010). Beekeeping provides an excellent source of income for the poor and landless farmers: since it is migratory in nature, even the landless farmers can take up this profession (Tarunika, 2014).

Drone-brood trapping has been shown to maintain low mite populations through the late summer when used without any other mite treatment, and it is unlikely that varroa mites will develop any behavioral resistance to this form of treatment (Tarpy, 2014).

This application of drone-brood trapping and subsequent freezing effectively kills the mites trapped within it (Calderone, 2015), but it also kills all of the developing drones. Genetic diversity is vital to the health of a colony, and this is accomplished when a queen honey bee mates with many drones. When the queen does not mate with a sufficient number of males, her colonies are often weaker and more susceptible to parasitism and disease (Tarpy, 2014). Current methods of drone-brood trapping result in a

decrease in the drone population available for mating with local queens. Also, exertion of selection pressure from mites on drones may result in increased survival of individuals that have increased mite tolerance.

Despite Ethiopia having a long historical background in Apiculture practice, the country still lacks technological advancements in this industry. The lack of modernization of apiculture is one of the major impediments to economic stability especially to peasant bee-keepers. The lack of modern equipment has led to production of low-quality bee products that fetch low prices. Ineffective institutional set-up and lack of policy review on beekeeping is also to blame for the underproduction of honey in the country (Getahun *et al.,* 2015).

Beekeepers harvest honey by cutting the combs which are then put in a container. Processing Honey should be processed as soon as possible after removal from the hive. Honey processing is a sticky operation, in which time and patience are required to achieve the best results. Careful protection against contamination by ants and flying insects is needed at all stages of processing. It is important to remember that, Honey is a food and it must therefore be handled hygienically, and all equipment must be perfectly clean and that honey is hygroscopic and will absorb moisture, therefore all honey processing equipment must be perfectly dry. Too much water in honey causes it to ferment (Honey Care Africa, Beekeeping in Africa Honey Care Agricultural Services Bulletin 68/6, 2010).

Smoking is used for masking the alarm pheromones like isopentyl acetate that used for moving honeybees from the honeycomb in the hive during harvesting and inspecting. Smoking required a careful follow up; unless it caused the melting of the honeybee wings, burning the hive, and so on at high temperatures. Modern beekeepers use a specialized tin can with bellows. They used it with non-harmful natural materials such as pinecones, wood chips, and cartons for fuel. They doused the fire and let the cinders burn to produces a smoke that is just the right temperature. When honeybees become alarming, beekeepers had begun smoking for interfering with honeybee's sense of smell, so that they could no longer detect the low pheromone concentrations (Gage *et al.*, 2018). However, the lower quality of honey harvested traditionally because smoking could be burnt effects on honey and attributed to the low quality of honey (Babarinde *et al.,* 2016).

Beekeepers in developing countries e.g., Kenya are also faced with the challenge of poor honey quality due to inadequate information on suitable technologies on harvesting, storage and processing. This in turn influences the rise and demand in internal and external markets technologies for bee product diversity. In these situations, development partners and the government need to come in and assist the farmers improve traditional bee keeping methods or introduce new technologies in new areas of apiculture (Jones, 2014). Although apiculture does not need high technology in practice, constant training is required by beekeepers on improving bee keeping practices.

Materials and methods

Study site

The present study was carried out between August-December 2020 in five Kenyan riparian counties (Siaya, Kisumu, Busia, Homabay and Migori) along Lake Victoria.

Target Population

The target population was 2415, 2018 beekeepers (questionnaire respondents) who directly deal with the bee brood, 181 bee apex organization members, 36 Non-Governmental Organizations representatives, 167 County Livestock Officers and 49 development partners in the five Kenyan Lake Victoria riparian Counties.

The study was carried out through a descriptive research design. A descriptive survey design is a research design that describes a phenomenon or characteristics associated with a subject population, estimate the proportion of a population that has these characteristics and discover associations among different variables (Cooper & Schindler, 2003).

Sampling procedure

A stratified random sampling and simple random sampling was used to select the respondents from each County (Table 1). Purposive sampling was used to select key informants from each County due to their knowledge and involvement in bee keeping.

Table 1. Sample Size Distribution.

Study Population	Target Population	Sampling Method	Sample Size	Data Collection Instruments
Beekeepers	2018	Simple random	263	Questionnaires
Bee apex organizations.	181	Purposive	50	FDG
Non-Governmental Organizations	36	Purposive	10	KII
Livestock Officers	131	Purposive	10	KII
Development. Partners	49	Purposive	10	KII
Total	2,415		343	

Source: Author (2022)

Sample Size Determination

Purposive sampling was used to select Siaya, Busia, Migori, Homabay and Kisumu Counties. The sample size will be generated according to Israeli, (2009) as shown below:

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

Where,

- n = desired sample size.
- N = Population size of the total households involved in the study.
- e = desired level of statistical precision. (±5 margin of error the precision level is 0.05).

Using this formula, the sample size was the generated as below:

$$n = \frac{2415}{1 + 2415(0.05)^2} = 343$$

Systematic sampling of bee keepers at interval of six derived from;

$$\text{Sampling interval} = \frac{\text{Total sample frame}}{\text{Sample size.}}$$

$$\text{Sample interval} = \frac{2,415}{343} = 7$$

Data analysis

The data was first imported to the Statistical Package for Social Sciences (SPSS) software for simple descriptive statistics and frequency analysis. During data analysis, results were summarized using descriptive statistics.

Regression analysis assumes that the independent variable ***x*** is at least in part a cause or a predictor of the dependent variable ***y***. These relationships will be used to draw conclusions on the contribution of value-added products of bee brood on the farm. Frequency means and standard deviation was used using descriptive statistics to summarize discrete data. During data analysis, results were summarized using descriptive statistics.

Table 2. Hypotheses Test.

Hypotheses Statement	Hypothesis Test	Decision Rule
H02: There is no significant relationship between extraction techniques and improved food security.	Karl-Pearson's coefficient of correlation -F-test (ANOVA) -T-test H01: $\beta 2 = 0$	Reject H01 if P- value ≤ 0.05 otherwise fail to reject H02 if P is > 0.05

Results and discussions

Extraction technologies have been acknowledged to be one of the factors that influence consumer acceptability of bee brood *(Apis mellifera)* as an alternative source of protein for improved food security.

Study Findings

Bee Brood Extraction Techniques

The study respondents were requested to show their level of agreement with the statements in relation to bee brood extraction techniques.

The variations in bee brood extraction techniques have been analyzed using t-value. The t-value shows how statistically significant are the differences in bee brood extraction techniques determinants. The results are as shown in Table 2.

The analysis in Table 2 shows that the majority who scored the highest mean of 3.89 and a standard deviation of 1.02 agreed that squeeze-method is a sustainable bee brood extraction method.

Table 3. Descriptive Statistics for Bee Brood Extraction Techniques One Sample t-test.

	N	Mean	Std. Deviation	T	P-Value
The traditional methods of extracting bee brood are unsuitable and unhygienic.	294	3.76	0.90	4.29	0.039
Warming is a sustainable bee brood extraction method	294	3.63	0.96	3.72	0.467
Hand removal is a sustainable bee brood extraction method	294	3.64	1.10	3.89	0.529
Freezing is a sustainable bee brood extraction method	294	3.31	1.05	1.93	0.621
Squeeze-method is a sustainable bee brood extraction method	294	3.89	1.02	5.15	0.011
N-Listwise	294				

This was closely followed by those who agreed that the traditional methods of extracting bee brood are unsuitable and unhygienic at a mean of (3.76) and a standard deviation of (0.90). Furthermore respondents agreed that warming is a sustainable bee brood extraction method with a mean of (3.64) and a standard deviation of (0.467). It implies that hand removal is not a sustainable bee brood extraction method (M=3.63,S.D.=1.0,P>0.05).

The findings imply that traditional methods of extracting bee brood and squeeze-method were statistically significant bee brood extraction techniques. While warming, hand removal and freezing are not significant. In the open-ended questions, the respondents were asked to state ways that extraction methods of bee brood influence consumer acceptability. In response the respondents were concerned about the bee brood palatability, purity, hygiene and specificity. The respondents were further asked to suggest how other ways do extraction methods of bee brood influence food security. The respondents were further asked to state other ways that extraction methods of bee brood influence food security in response the respondents suggested that extraction methods determine quantity and quality, influences color and nutrients and consumption levels.

The respondents were further asked to recommend other bee brood extraction methods. Of which they suggested hot water bath method, smoking, hand picking and technological method.

Bee Brood Extraction Techniques Correlation Analysis

The study sought to establish the relationship between the socio-economic factors and consumer acceptability of bee brood (*Apis mellifera*) as an alternative source of protein for improved food security. The findings are presented in Table 3.

Table 3. Correlation analysis between bee brood extraction techniques and improved food security.

		Food Security	Extraction Techniques
Food Security	Pearson Correlation	1	0.311**
	Sig. (2-tailed)		0.000
	N	294	294
Extraction Techniques	Pearson Correlation	0.311**	1
	Sig. (2-tailed)	0.000	
	N	294	294

**. Correlation is significant at the 0.01 level (2-tailed).

The correlation coefficient r = 0.311, p=0.000 implies that there is a positive relationship between bee brood extraction techniques and improved food security. This conclusion implies that bee brood extraction techniques are a significant predictor of improved food security.

Bee Brood Extraction Techniques Response Regression Analysis

Simple Linear regression test was run to determine the predictive power of bee brood extraction techniques on consumer acceptability of bee brood *(Apis mellifera)* as an alternative source of protein for improved food security results are shown in Table 4.

Table 4. Model Summary.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.311[a]	0.097	0.094	0.67904

a. Predictors: (Constant), Bee Brood Extraction Techniques

Table 4 shows R Square of 0.097 implying that bee brood extraction techniques determine 9.7% variations in consumer acceptability of bee brood *(Apis mellifera)* as an alternative source of protein for improved food security.

Table 4. Relationship between Bee Brood Extraction Techniques and Improved Food Security.

ANOVA[a]					
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	14.448	1	14.448	31.3340.000[b]
	Residual	134.638	292	0.461	
	Total	149.086	293		

a. Dependent Variable: Improved Food Security

b. Predictor: Bee Brood Extraction Techniques

The probability value of p<0.000 indicates that the regression relationship was significant in predicting how bee brood extraction techniques influence improved food security. The researcher further sought to establish the level at which bee brood extraction techniques influence improved food security. The results were shown in Table 5.

Table 5. Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.066	0.280		7.3660.000	
	Extraction	0.426	0.076	0.311	5.5980.000	

a. Dependent Variable: Improved Food Security

From Table 4.5 results, it was observed that holding bee brood extraction techniques to a constant zero, improved food security would be at 2.066. Thus, a unit increase in socio-economic factors would lead to increase in improved food security as food by factor 0.426.

Independent Variables Coefficients Summary per County

The study sought to establish which independent variable (socio-economic factors, extraction techniques, county government support) influence improved food security most in the five Counties. Pearson's coefficient of determination was used. The results are as shown in Table 6.

Table 6. Independent Variables Coefficients Summary per County.

County	Constant	Extraction Techniques
Siaya	3.182	0.102
Migori	1.159	0.474
Kisumu	1.383	0.480
Busia	1.691	0.412
Homabay	0.531	0.461

The findings reveal that bee brood extraction techniques influence improved food security in Busia County, Kisumu County, Homabay County, Migori County and Siaya County.

Conclusion

The objective of the study was to analyze the influence of bee brood extraction techniques on acceptability of bee brood *(Apis mellifera)* as an alternative source of protein for improved food security. The findings showed that squeeze-method is a sustainable bee brood extraction method. The traditional methods of extracting bee brood are unsuitable and unhygienic. Furthermore respondents agreed that warming is a sustainable bee brood extraction method. It implies that hand removal is not a sustainable bee brood extraction method (M=3.63,S.D.=1.0,P>0.05).

Recommendations

The objective of the study was to analyze the influence of bee brood extraction techniques on acceptability of bee brood *(Apis mellifera)* as an alternative source of protein for improved food security. This study sought to establish whether traditional methods, warming, hand removal, freezing and squeeze-method influence acceptability of bee brood *Apis mellifera)* as an

alternative source of protein for improved food security. It was found that the highest mean of 3.89 a standard deviation of 1.02 agreed that squeeze-method is a sustainable bee brood extraction method. This was closely followed by those who agreed that the traditional methods of extracting bee brood are unsuitable and unhygienic. Furthermore respondents agreed that warming is a sustainable bee brood extraction method. It implies that hand removal is not a sustainable bee brood extraction method. The correlation coefficient r = 0.311, p (0.000) <0.5.

In the interest of biosecurity, it is recommended that beekeepers disinfect beekeeping equipment that comes in contact with bees. This includes the disinfection of dead-out hive boxes and frames and regular disinfection of tools, such as hive tools and smokers. Used equipment should be disinfected (irradiation, acetic acid, ozone) before being re-used in the operation. Irradiation in particular is highly recommended to prevent AFB transmission, whereas acetic acid fumigation is a routine preventative method to guard against Nosema and Varroa mites.

Beekeeping equipment should be sterilized regularly when moving between bee yards. Hive tools should be scraped clean and heated to a high temperature, as should smoker bellows. Leather gloves can be exchanged for disposable gloves or used in conjunction with rubber gloves for ease of sterilization. Special precaution should be taken around equipment with greater risk of contact with wax and honey that may contain AFB spores.

Acknowledgements

My appreciation and gratitude goes to all those that gave their input tremendously towards completion of this paper. This paper could not have been made possible without the advice and support of my University supervisors, Prof. Christopher Obel Gor and Dr. Mary Orinda for their tireless assistance, high quality, invaluable support and keenness on details, experience and initiatives which guided me in enriching and completing this paper. I also wish to sincerely acknowledge the support from all my lecturers in the doctoral studies program for their dedication, patience and humility to see me this academic endeavor.

I extend my deepest appreciation to my colleagues and friends, respondents and all who contributed in one way or the other. To my loving family, I have special thanks for them. Lastly, but not least, thanks to the Almighty God for giving me sufficient grace.

References

Ajzen I. 1975. Effects of information on interpersonal attraction: Similarity versus affective value, Journal of Personality and Social Psychology **29(3),** 374-380.

Ajzen I. 1985. From intentions to actions: A theory of planned behavior. In J. Kuhi& J. Beckmann (Eds.), Actionó control: From cognition to behavior. Heidelberg: Springer.

Ajzen I. 1991. The theory of planned behavior, Organizational Behavior and Human Decision Processes **50(2),** 179-211.

Ajzen I. 2002. Perceived behavioral control, self-efficacy, locus of control, and the theory of planned behavior, Journal of Applied Social Psychology **32(4),** 665-683.

Alemu M, Olsen S, Vedel S, Kinyuru J, Pambo K. 2017a. Can insects increase food security in developing countries. An analysis of Kenyan consumer preferences and demand for cricket flour buns.Food Security **9(3),** 471-484.

Annette BJ. 2015. Association of Officiating Analytical Chemists. (1996). Official methods of analysis (16thed.). Washington, DC: Author.

Breed MD, Moore J, 2016. Animal Behavior (Second Edition), Homing in Bee Foraging, https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/apis-mellifera

Carroll T, Kinsella J. 2013. Livelihood improvement and smallholder beekeeping in Kenya: the unrealized potential, Development in Practice **23(3),** 332-345.

CTA Spore. 2017. Bee products: Honey exports take off in Africa. Retrieved from

Engel MS. 2012. The honey bees of Indonesia (Hymenoptera: Apidae). Treubia **39,** 41-49.

FAO. 2010. "The state of food in severity to the world how does international price volatility affect domestic economies and food security?" Food and Agriculture Organization of United Nations, Rome.

FAO. 2013. Edible Insects: Future Prospects for Food and Feed Security. Forestry Paper No.171.

Golag LNRS, Anderson DL, Oldroyd BP. 2010. "A molecular phylogeny of the genus *Apis* suggests that the Giant Honey Bee of the Philippines, A. breviligula Maa, and the Plains Honey Bee of southern India, A. indica Fabricius are valid species". Systematic Entomology **35(2),** 226-233.

Jokonya O. 2015. Validating Technology Acceptance Model (TAM) during IT Adoption in Organizations, Journal of Food, Agriculture & Environment **7(3),** 509-516.

Koeniger N, Koeniger G, Smith D. 2011. Phylogeny of the genus *Apis*. In: Hepburn & Radloff (eds.): Honeybees of Asia. Springer-Verlag, Berlin pp. 23-50.

McEachan RC, Conner M, Taylor N, Lawton RJ. 2011. Prospective prediction of health-related behaviors with the theory of planned behavior: A meta-analysis. Health Psychology Review **5,** 97-144.

Oonincx DGAB, Van Itterbeeck J, Heetkamp MJW, Van Den Brand H, Van Loon JJA, Van Huis A. 2010. An exploration on greenhouse gas and ammonia production by insect species suitable for animal or human consumption. PloS ONE, 5(12), 1–7. Organization of the United Nations Roma, 24th ed pp. 253.

Rumpold B, Schlüter O. 2013. Nutritional composition and safety aspects of edible insects. Molecular Nutrition and Food Research **57(2),** 802-823.

Sheeran P, Gollwitzer PM, Bargh JA. 2013. Nonconscious processes and health. Health Psychology **32(6),** 460-473.

Tabinda. 2013. "Impact Assessment of Beekeeping in Sustainable Rural Livelihood" Journal of Social Sciences Vol. **2 No.2,** p. 1.

Tarekegn K, Haji J, Tegegne B. 2017. Determinants of honey producer market outlet choice in Chena District, southern Ethiopia: a multivariate probit regression analysis, Journal of Agricultural Economics **5(20),** 456-478.

Tarunika JA. 2014 "Beekeeping Industry in India: Future Potential "Impact: International Journal of Research in Applied, Natural and Social Sciences, Vol. **2(7)** pp. 133-140

Taruvinga A, Mushunje A. 2018. Factors that influence smallholder beekeepers' selection choices of honey value addition initiatives, Journal of Advanced Agricultural Technologies **5(3),** 23-34.