DEVELOPMENT, NUTRIENT COMPOSITION AND ACCEPTABILITY OF TAMARILLO HONEY JAM AMONG PRESCHOOLERS AND ADULTS IN LURAMBI SUB-COUNTY, KAKAMEGA.

OPO ASIANUT DORCAS

A Thesis Submitted to the School of Public Health, Biomedical Sciences and Technology in Partial Fulfillment for the Requirements of the Award of Master of Science in Public Health Nutrition Degree of Masinde Muliro University of Science and Technology

September, 2023

DECLARATION

This thesis is my original work prepared with no other than the indicated sources and support and has not been presented elsewhere for Award of a degree.

Opo Asianut Dorcas

HPN/G/01-54045/2019

Date……..

Signature…….

SUPERVISOR(S) DECLARATION

The undersigned certify that they have read and hereby recommended for acceptance of Masinde Muliro University of Science and Technology thesis entitled '***Development, Nutrient Composition and Acceptability of Tamarillo Honey Jam among Preschoolers and Adults in Lurambi Sub-County, Kakamega.'***

Prof. Asenath Sigot

Signature…… Date……

Department of Nutritional Sciences

Masinde Muliro University of Science and Technology

Dr. Anne Aswani Musotsi

Signature…… Date……

Department of Nutritional Sciences

Masinde Muliro University of Science and Technology

PLAGIARISM STATEMENT

1. I hereby declare that I know that the incorporation of material from other works or a paraphrase of such material without acknowledgement will be treated as plagiarism according to the Rules and Regulations of Masinde Muliro University of Science and Technology.
2. I understand that this thesis must be my own work.
3. I know that plagiarism is academic dishonesty and wrong, and that if I commit any act of plagiarism, my thesis can be assigned a fail grade ("F").
4. I further understand I may be suspended or expelled from the University for Academic Dishonesty.

Opo Asianut Dorcas Signature……

HPN/G/01-54045/2019 Date……

DECLARATION BY THE SUPERVISORS

I/We declare that this thesis has been subjected to plagiarism check at the University Library and its similarity index is not above 20%.

Prof. Asenath Sigot
Signature…… Date……
Department of Nutritional Sciences
Masinde Muliro University of Science and Technology

Dr. Anne Aswani Musotsi
Signature…… Date……
Department of Nutritional Sciences
Masinde Muliro University of Science and Technology

COPYRIGHT STATEMENT

ACKNOWLEDGEMENT

Foremost, my utmost gratitude goes to my supervisors Prof. Asenath Sigot and Dr. Anne Aswani who guided and supported the actualization of this thesis. All my lecturers for their mentorship and unwavering support that shaped me into the person I am.

My sincere appreciation to my classmates Kimutai Sagam, Ruth Nabwoba, Zadok Maingi, Kaesha Pauline with whom we have burnt the midnight oil and held tightly to the phrase “Doing the best at this moment puts you in the best place for the next moment”. The entire MMUST fraternity staff who have contributed to the success of this work.

To all my dear friends who have continually encouraged and held my hand, went through my work and gave a listening ear over and over and my loving husband Dennis who persistently reminded me to keep the focus.

To my aunt Claire who has played a key role in the brainchild of this entire project. To my lovely family; my parents whom am greatly indebted for literally everything, my siblings who have pushed and encouraged me through and through.

Finally, the Almighty God has been the Alpha and Omega in the whole process.

ABSTRACT

Fighting malnutrition in all its forms among adults and children is still a great challenge in the 21st century. Utilization of fruits in jam production has been on the rise. Exploring the use of honey for food value addition has also gained popularity. Tamarillo fruit has a high antioxidant activity, contents of carotenoids, ascorbic acid, Vitamin B6, minerals and provitamin A. Globally, it is an underutilized, sustainable fruit crop with great potential for value-added products preparations such as salads, sauces, soups, jams, ice creams, juices and liqueurs. In Kenya, tamarillo has gained traction in the recent past due to the increasing awareness of its immense nutritional value and economic potential. The study sought to develop tamarillo honey jam, determine its nutrient composition, safety and acceptability among 103 preschoolers (4-5) years and 48 adults (Parents and teachers) (25-60) years. Fresh and ripe tamarillo fruits were collected with honey from Kitale and Marigat bee farms. The fruits were sorted, washed and the outer cover peeled off. The pulp was then blended to reduce the cooking time of the pulp to preserve the nutrients and separated from the seeds by sieving. The pulp was cooked at 95°C. After 10 minutes pectin and honey were added by constantly stirring using a moderate fire. Potassium sorbet and sodium benzoate were added and stirred to mix uniformly before being left to cool and set. The jam was packaged in sterilized containers and sealed. The proximate, micronutrient composition and safety analysis were done and later the sensory attributes were tested to ascertain its acceptability among preschoolers and adults. The parameters used in sensory evaluation were; smell, appearance/colour, mouth feel, taste, fluidity and general acceptance. The parameters were subjected to a 9-point hedonic scale and the research assistants recorded the feedback of the preschool children without any external influence. For adults, a focus group interview guide was used in discussion groups. The researcher sought responses on; how familiar they were with the jam, what are the things they like and do not like about the jam, what would most likely influence them to buy the jam and their recommendations. Data analysis used NVIVO 20 for qualitative analysis and SPSS version 25 for the descriptive statistics. Developed tamarillo jam consisted of 64.93% of fruit pulp, 32.45% of honey, 2.59% of pectin and 0.03% of the preservatives. Moisture content 21.5%, crude protein 0.1%, Fat content 0.36%, sugar content 30.32%, crude fibre 0.02%, total ash 0.22%, carbohydrates 77.82%, Zinc 0.03mg/100g, Iron 0.08mg/100g, Potassium 0.01mg/100g, Sodium 1.09mg/100g, Magnesium 2.3mg/100g, Vitamin A 0.3 µg/100g, Vitamin E 0.2 µg/Kg, Vitamin B 0.16 µg/Kg and Vitamin C 49.63 µg/Kg. The safety analysis indicated Coliform <10 cfu/g, Escherichia coli undetected, Salmonella spp undetected and Yeasts and Moulds <10 cfu/g. More than 75% of both adults and preschoolers liked the jam with less than 25% having negative taste preferences. The findings revealed that tamarillo jam was acceptable among the adults and preschoolers. Findings indicate that honey can be incorporated in jams for consumption of variety value added nutritious products and help address nutritional concerns alongside diets. Tamarillo honey jam is a rich source of energy from the natural honey incorporated with distribution of other micronutrients and less in fat.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

AAS	:	Atomic Absorption Spectrophotometry
AOAC	:	Association of Official Analytical Chemists
HPLC	:	High Performances Liquid Chromatography
KDHS	:	Kenya Demographics Health Surveys
KEBS	:	Kenya Bureau of Standards
KIRDI	:	Kenya Industrial Research and Development Institute.
KNBS	:	Kenya National Bureau of Statistics
MNDS	:	Micronutrient Deficiencies
MUAC	:	Mid-upper Arm Circumference
RDA	:	Recommended Dietary/Daily Allowance
RDI	:	Recommended Dietary Intake
SDGs	:	Sustainable Development Goals
SPSS	:	Statistical Package for Social Sciences
TBM	:	Triple Burden of Malnutrition
UHC	:	Universal Health Coverage
UNICEF	:	United Nations International Children's Fund
WHO	:	World Health Organization
ISO	:	International Standards Organization

ADOPTED DEFINITION OF TERMS

Acceptability : the verification or acceptance that a manufactured item meets required specifications or standards and is usable for its purpose.

Characterization **:** these are the biochemical and biophysical nature of a product as well as the nature of product-related substances and impurities.

Development : refers to the creation of a new product which has some utility; or up-gradation of the existing product; or enhancement of the production process, method or system.

Innovation **:** a novel approach to production of known goods, discovery and production of new types of products as well as introduction to the market of new production combinations to satisfy consumer's ever-changing needs. Also the ability to apply creative solutions to problems and opportunities to enhance or enrich people's lives.

Jam : defined as an intermediate moisture food prepared by cooking sugar and or sugar substitute like honey with fruit pulp, acid and other ingredients to achieve a sensible consistency.

Organoleptic **:** these are aspects of or pertaining to the sensory properties of a particular food or chemical, the taste, colour, odour and feel.

Preschool children **:** these are children who are no longer babies but are not yet old enough to go to school, they attend preprimary educational centers before commencement of compulsory primary education aged between 4-5 years.

Sensory evaluation **:** this is a science that measures, analyzes, and interprets the reactions of people to products as perceived by the senses. It is a means of determining whether product differences are perceived, the basis for the differences, and whether one product is liked more than another.

Tamarillo **:** small tree or shrub in the flowering plant family Solanaceae (the nightshade family). It has a distinctive acidic flavor, an attractive deep skin and flesh with a life expectancy of 5-12 years with perennial leaves and strong musky smell.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Triple burden of malnutrition which entails micronutrient deficiency, overweight and obesity and under nutrition has been a major drawback globally as a greater contributor to morbidity and mortality rates ((NDC), 2018). This has affected both adults and children equally. According to global report, 2.37 billion people could not access adequate food in 2020 with 45.4 million children under the age of five being wasted (FAO *et.al,* 2021). Worldwide the burden of micronutrient deficiency of key minerals like either Zinc, Iron or Vitamin C is 56% for preschoolers and 69% for reproductive age women (Stevens *et.al,* 2022). Micronutrient deficiency leads to unrealized human potential and low economic productivity in any society. It also leads to increased mortality and morbidity rates, impaired physical and mental growth (Miller & Welch, 2013). Food value addition and preventing food loss is an important strategy in addressing food insecurity issues through provision of safe, healthy, long lasting and nutritious variety products (FAO *et.al*, 2021).

Fruits have a high nutrient density in terms of minerals, trace elements and vitamins, high dietary fibre content, lowered energy density and various dietary bioactive components like polyphenols, terpenes and betalains. (Wallace *et al*., 2020). In cases of preschoolers, who are in the early stages of child development, they tend to be responsive on dietary changes with long-term effects on lifestyle (Nicklaus *et al*., 2023). Therefore, the above may inform strategies like further research for fruits, which are a good target with the goal of identifying effective policy approaches and interventions for food security and

nutritious food choices while providing fruits to preschoolers. (Donadini *et al*., 2022). Recent initiatives to combat malnutrition in all its forms has led to a decrease in micronutrient deficiencies. Increasing production and processing of micronutrient rich foods fruits inclusive, leads to a decline in malnutrition status of the population. Food based strategies have proved effective in promoting diversification and consumption of nutrient rich foods (FAO, 2011). Evidence from studies demonstrate the immense benefits of fruits in disease prevention and promoting health of individuals.

Tamarillo fruit (Cyphomandra betacea) which is native of Andean regions of South America, Peru, Ecuador, Argentina and Bolivia is a small tree, rather shrub in the flowering plant family Solanaceae (the nightshade family) (Wang et al., 2020). Tamarillo possess properties that are increasing its demand in the market which include; a high antioxidant activity, contents of carotenoids, ascorbic acid, Vitamin B6 and provitamin A (Acosta-Quezada *et al*., 2016). It possesses various other names including; tree tomato, tomate de yuca, tomate andino, tamamoro, tomate serrano, sachatomate, berenjena, and tomate de arbol in South America (Anon (2018).

Tree tomato and tamarillo has been used interchangeably to refer to the same fruit. Utilization of tree tomato fruit in Africa is among the fast-growing techniques being incorporated in our dishes. Tamarillo has over the years been planted with few individuals who happened to have prior necessary knowledge. In Kenya it has been grown in different areas among them are; Kakamega, Migori, Meru, Nyandarua, Nyeri, Kericho. Most farmers have been producing it for household consumption and few for market use (Greenlife, 2023). Tamarillo is utilized raw as a fruit, as an appetizer, as a salad and in other food preparations such as sauces, soups, jams, ice creams, juices and liqueurs. It is

highly coveted in food industries for processing due to its high levels of pectin used in production of preserves and jams, production of dairy products like ice creams, yoghurts and shakes. Other products like chutney, baby food and sauces are produced due to its desirable property of canning in syrup (Joshi, 2018).

Jam is a thick spread made from entire fruits inclusive of the fruit pulps. The fruits are combined with table sugar and heated until an even consistency is attained then packed in storage containers (Ullah *et al*., 2018). The table sugar used, commonly referred to as sucrose, is refined through an industrial process. It is a combination of two disaccharides, glucose and fructose at 50% each with added ingredients (Bobiş *et.al*, 2018). Jams could also mean an intermediate moisture food prepared by cooking table sugar with fruit pulp, acid and other ingredients to achieve a sensible consistency (Ullah *et al*., 2018). Jams are not consumed as whole meals instead are used in breads and scones as spreads and incorporated in other food recipes. They are prepared and served while cold and at room temperature.

This study sought to incorporate honey which is a combination of monosaccharides fructose (35–40%) and glucose (30–35%) with fructose being a naturally occurring sweetener that is the sweetest instead of table sugar in the formulation of tamarillo honey jam (Bobiş *et.al*, 2018). Honey was utilized due to its high nutritional value and medicinal properties. Honey can impede the growth of pathogens like *Bacillus subtilis*, *Escherichia coli* and *Pseudomonas aeruginosa* (Ferreira *et al*, 2019). Honey also showed success against *Salmonella enterica Typhi* and *Pseudomonas aeruginosa* which are human health important bacteria in vitro studies. It has also demonstrated antiviral properties and an example of Manuka honey, which was found to be useful in inhibiting the influenza virus

activity. Influenza virus which is a threat to human health both among children and adults and infectious respiratory disease transmitted by coughing and sneezing through air (Ferreira *et al*, 2019). Unlike table sugar honey has a lower glycemic index, contains polyphenols, trace elements, vitamins, enzymes and proteins in small amounts (Bogdanov *et al*., 2008). Several studies show honey as a source of natural healing. Honey is also rich in components such trace elements, proteins, vitamins, organic acids, flavonoids, phenolic acids, and enzymes. It possesses various properties of benefit to human health. It has antioxidants, antimicrobials, anti-inflammatory, antidepressant, and hepatoprotective and immunomodulation activity (Keskin *et al.,* 2021). According to (Bogdanov *et al.,* 2008), moderate consumption of honey does not lead to hyperglycemia due to the slow process of conversion of levulose also known as fructose. This allows quality time for elimination of sugar by the human body. This proves why honey can be incorporated in the stabilized diabetic patients' diet posing a lesser risk than the common sugar.

This study focused on tamarillo honey jam development as a possible solution to addressing fruit value addition, food security and tamarillo honey jam acceptability among preschool children and adults (Parents and teachers) (25-60) years. The study was conducted in Kakamega County with a keen focus on Lurambi Sub County.

1.2 Statement of the problem

Fighting malnutrition in all its forms poses a greater challenge in the 21st century. The incorporation of high quantities of refined table sugar in our food products in the recent past poses a threat to the health of individuals. Consumption of unhealthy diets is a

significant cause of malnutrition resulting to high disability and mortality rates among adults and children (WHO *et.al*, 2014). Table Sugar commonly known as sucrose is classified as a high glycemic index (60) food posing as a risk for hyperglycemia, increased weight gain and coronary heart disease unlike honey (Bobiş *et.al*, 2018).

The Kenya National Nutrition Action Plan (KNAP, 2018-2022), seeks to enhance uptake of diversified, and bio-fortified foods among its key components of prevention, control and management of micronutrient deficiencies. Existing strategies include; first, promoting increased access to nutritious and safe food along the value chain pathways and secondly, promoting increased consumption of safe, diverse nutritious foods (KNAP, 2018-2022). A nutrition intervention of providing tamarillo honey jam accompanied by key health messages is one of the strategies that can be employed. This will help in addressing the triple burden of malnutrition; which includes micronutrient deficiency, overweight and obesity and under nutrition that has been a major drawback globally and a greater contributor to morbidity and mortality rates (NDC, 2018). Both adults and children at the age of five and below are the ones equally affected, there is great need in incorporating the macro and micronutrients in a diverse diet that is easily available, acceptable and accessible (FAO *et.al*, 2021), (KNAP, 2018-2022).

Globally, tamarillo fruit has been underutilized yet it is a nutrient dense fruit. Tamarillo fruit has a low fat content and low calories. It is a source of soluble sugars, proteins, dietary fibre, minerals like iron, zinc, phosphorus, Magnesium, potassium, Calcium and copper and Vitamins like C, A, E and B6 (Wang *et al.,* 2020). Amounts of vitamins B_6, C and E and of trace elements such as iron, magnesium, copper and potassium present in

one tamarillo fruit may supply over 5% of the RDI (recommended daily intake) of these nutrients (Lister *et al*., 2005).

Honey being rich in trace elements, proteins, vitamins, organic acids, flavonoids, phenolic acids, and enzymes. Possessing various properties of benefit to human health having antioxidants, antimicrobials, anti-inflammatory, antidepressant, and hepatoprotective and immunomodulation activity (Keskin *et al.,* 2021). A clinical study on use of honey in treatment of diabetes revealed reduction of 1.3% in body weight, 3% total cholesterol, 11% triacylglycerol, 1.1% body fat in the control group after administration of 70g/day of honey in 30 days by (Bobiş *et.al*, 2018). The use of honey as a substitute sweetener for refined table sugar is an increasing growth area. (Sharma *et.al*, 2016).

Incorporation of honey in tamarillo jam development as the sweetening agent instead of sugar is key in developing a healthy and nutritious product for all age consumers. This study therefore sought to fill the gap by developing tamarillo honey jam, determining its nutrient analysis and acceptability among children and adults.

1.3 Objectives of the Study

1.3.1 Broad Objective

To develop tamarillo honey jam, determine its nutrient composition, safety and acceptability among preschoolers (4-5) years and adults (Parents and teachers) (25-60) years.

1.3.2 Specific Objectives

1. To establish a protocol for preparation of tamarillo honey jam.
2. To determine the proximate and some micronutrient composition of developed tamarillo honey jam.
3. To establish the microbiological limit of yeasts and moulds, salmonella and Escherichia coli, safety and quality standards of developed tamarillo honey jam.
4. To determine the acceptability and sensory evaluation of tamarillo honey jam on preschool children (4-5) years and adults (Parents and teachers) (25-60) years.

1.4 Research Question

1. What is the protocol for preparation of tamarillo honey jam?
2. What is the proximate and micronutrient composition of tamarillo honey jam?
3. What are the microbiological limit of yeasts and moulds, salmonella and Escherichia coli, safety and quality standards of developed tamarillo honey jam?
4. What is the acceptability and sensory evaluation of tamarillo honey jam on preschool children (4-5) years and adults (Parents and teachers) (25-60) years?

1.5 Justifications of the study

The study sought to develop a new nutritious product that will be acceptable to both children and adults. This study utilized tamarillo fruit which is low in fat content and low calories and a source of soluble sugars, proteins, dietary fibre, minerals like iron, zinc, phosphorus, Magnesium, potassium, Calcium and copper and Vitamins like C, A, E and B6 to make jam as way of promoting value addition and minimizing post-harvest losses. The study also incorporated natural unprocessed honey in tamarillo fruit to make jam. Honey being a highly nutritious sugar substitute associated with decreased blood glucose levels, weight loss, lowered coronary heart disease. Unlike refined table sugar honey has

a lower glycemic index, contains polyphenols, trace elements, vitamins, enzymes and proteins in small amounts. Key area was to provide a complete product that promotes the health benefits of both tamarillo and honey contributing to food security. Children at this age are at higher risk of both macro and micronutrient deficiencies due to poor feeding habits, food choices and food insecurity. Adults are key caregiver of the preschool children hence influence a lot of their food choices and feeding habits. They contribute also to the pillars of food security that is; food accessibility, availability and affordability since children cannot fend for themselves. Adults are also at a greater risk of food insecurity. The findings of the study may be useful in shaping consumer knowledge on product acceptability and food choices. According to Kenya Spreads Market analysis, there is increasing introduction of real fruit jam with value addition apart from the flavoured jams in the market. Tamarillo honey jam may form part of the variety healthy fruit jam in the market.

1.6 Significance of the study

Fruit value addition is one of the key factors that aim at improving individuals and society's health and curbing food insecurities. Tamarillo honey jam development, nutrient analysis and acceptability test is among examples that can be recommended as a value added jam in our shelves. The findings of the study are useful in addressing SDG 2 that focuses on ending hunger, achieving food security and improved nutrition and promoting sustainable agriculture by providing a healthy jam from local farm products that addresses food security (Grosso *et.al*, 2020). The findings of this study will contribute to the achievement of SDG 3 that focuses on ensuring healthy lives and promoting the wellbeing of individuals at all ages. The findings of the study will also contribute in provision of

key nutrition knowledge that will inform improved nutrition practices among parents and teachers of preschool children. This study will also document gaps that exist in product development and analysis. Finally, the findings of this study will be documented and will form part of nutrition action plan strategies.

1.7 Limitations of the Study

This study had several limitations. During development, it was limited to panelists at the area of production, which may result to some bias. The findings were limited to the respondents available during the time of study therefore; findings may be biased in terms of gender since not all gender was equally represented. The data collection tool for acceptability of tamarillo honey jam, findings were limited to one time reporting. This may not provide comprehensive use of the jam over a period of time. It was also limited to the specific age group stated in the study, which is children (4-5) years and adults (25-60) years which may not draw conclusions from the entire population for all ages resulting to some bias. On the data collection area, was limited within Lurambi, Sub County of Kakamega which may not necessarily represent the views of other sub counties within the county.

1.8 A Conceptual Framework

Product acceptability is determined by availability of the product, that is; the production phase to packaging and labelling the product, necessary product safety measures and acceptability tests. The conceptual framework Fig 1.1 shows the perceived link between the independent and dependent variables.it shows that product analysis is dependent on development of that particular product. It also demonstrates how the acceptability of tamarillo honey jam among Preschoolers (4-5) years and adults (Parents and teachers) (25-60) years is dependent on the product sensory evaluation parameters which are usually observed during the acceptability testing which include; smell, appearance/colour, mouth feel, taste, fluidity and general acceptance.

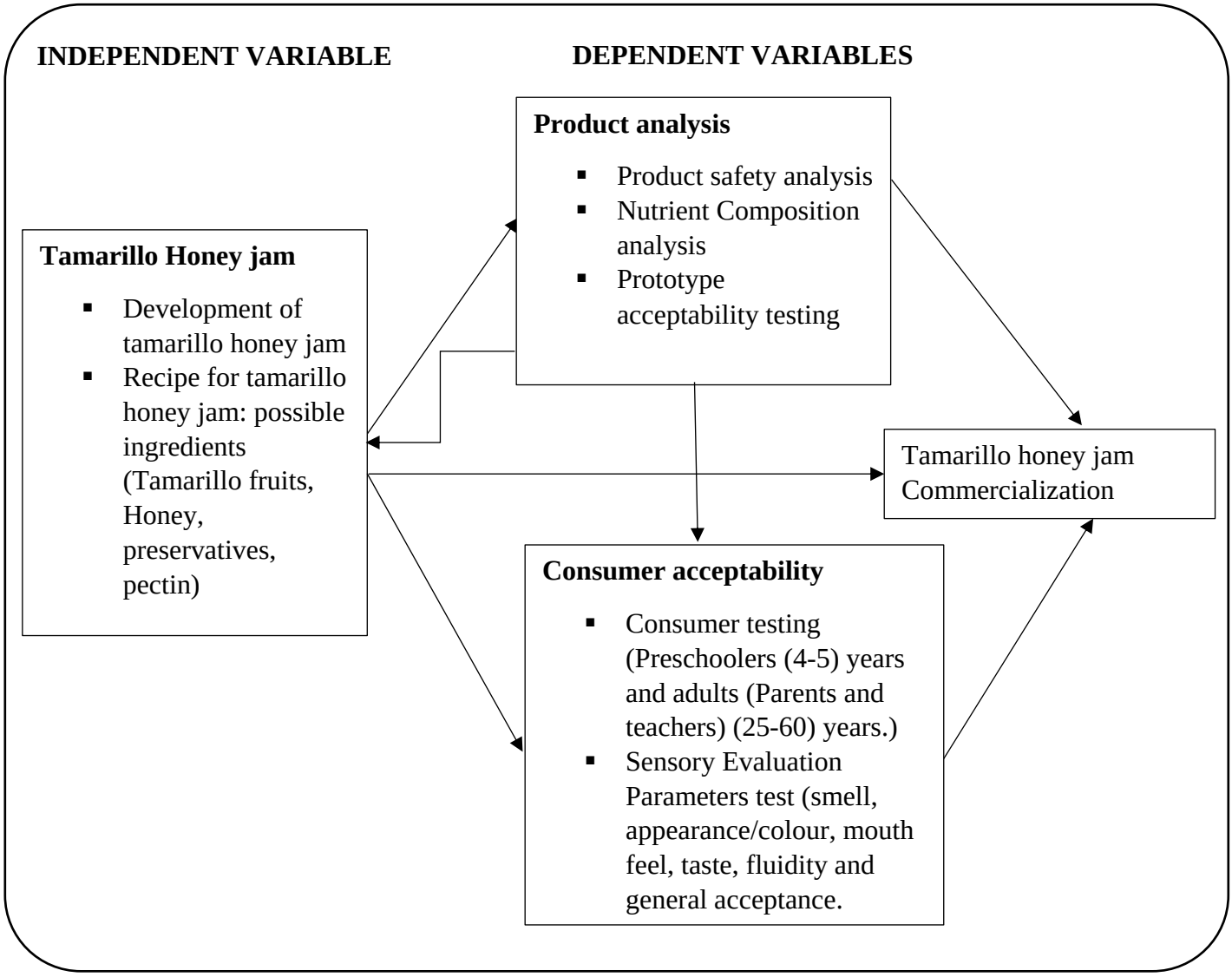


Figure 1.0.1: *A conceptual framework for tamarillo Honey Jam*

Product innovation seeks to tap on the previous untapped market and the already existing markets to meet the needs of the society. Several studies have been conducted and product innovation and development is among the many outlining the specific and various steps a product undergoes before successfully launching it to the commercial space. The concept of product innovation and development involves various stages. The initial stage, which is coming up with the idea on the type of innovation after establishing the needs of population. The best idea is then selected and followed by its development. During the process if the selected idea fails, it is redirected back to the creativity stage. When the developed idea succeeds, it proceeds to the implementation stage (Tufan Ekrem and *et al.*, 2017). The selected product is then developed and undergoes rigorous tests which involves testing with small samples of customers to provide room for continuous improvements. The customers' feedback is vital from the testing stage and until the last version of the product is decided on for launch on the commercial space. The final users' input (customer feedback) is highly recommended for keeping the development on the right direction. The testing process of the product is continuous even after the product launch for future prediction of the innovation. Customer's feedback and the value characteristics to the customer is prioritized rather than the product itself. This is then followed by commercialization which involves introduction of the innovated product to the market through a designed business plan. The business plan will provide a framework for finances, operation of terms and marketing of the product. After successful market testing of the product, a feasibility study is done. The study entails thorough research on financial and legal restrictions involved in launching the product into the market. At this

point the sales forecast are created; this involves overall costs of production, estimation of the profits of the product and establishing the price (Tufan Ekrem and *et al.,* 2017).

Tamarillo honey jam is an innovative idea well thought of based on the increasing nutritional and health needs of children and adults within the current society. This ideas seeks to be actualized through development of the jam by exploring possible ideas around the correct ingredients to be used and getting a standard recipe for the product. This involved logistical planning of acquisition of the necessary raw materials followed by formulation of the prototype jam. The prototype was then subjected to a pilot test with a few consumers continuously to help improve the quality of the product. The product was then analyzed to determine its nutritional content and establish its safety standards at Kenya Industrial Research and Development Institute (KIRDI) and Kenya Bureau of Standards (KEBS) respectively. After successful analysis, the product was subjected to acceptability test by target consumer population that is children and adults. Consumer feedback was used to determine the acceptability score of the jam. The negative feedback was cross examined before redoing the test. For positive test, the product was proved effective and hence proceeded to commercialization. The above highlighted steps have been summarized in figure 1.1.

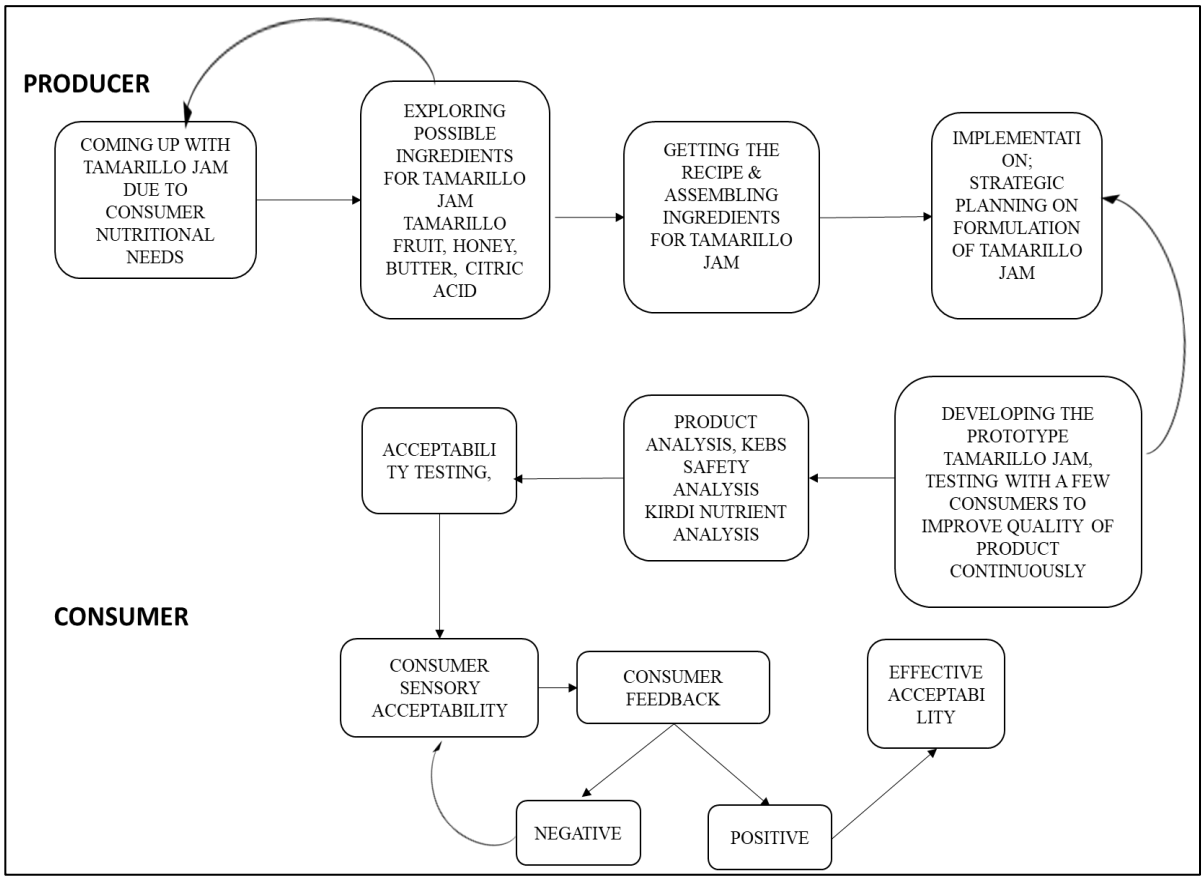


Figure 1.0.2 *A workflow for tamarillo jam innovation, adopted and modified (Tufan Ekrem and et al., 2017)*

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter reviewed literature in line with the study objectives. It delved into identifying the key contribution of authors to the research topic and also key knowledge gaps in the study. It covered the formulation of jams, origin of tamarillo, its nutrient and chemical composition, physical and functional activity, nutritional indicators and product acceptability.

2.1 Formulation and development of jams

Traditionally, jams were produced in order to preserve fruits during off season for consumption. They are among the popular food products due to their availability, low costs and organoleptic properties. Jams are an intermediate moisture food prepared by cooking sugar with fruit pulp, acid and other ingredients to achieve a sensible consistency (Ullah *et al*., 2018). During manufacturing, the raw materials, sugar and fruits are mixed in same proportion. Citric acid is also added to improve acidity of the fruit and pectin is also added to fruits with low pectin levels to help in gel formation (Nations, 1992). The mixture is then cooked to produce delicious product with a longer shelf life. Several fruits have been used to add value to food products like jams (Mohd *et al.*, 2017). Some of the attributes of jams increase during the storage period like the total soluble solids, reducing sugars which could possibly be as a result of reversed disaccharides like sucrose to monosaccharides glucose and fructose. The acidity of the jams tend to increase as shown in the case of coconut based jam, mixed fruit jam and poniol fruit jams (Rana *et al.*, 2021).

The proposed prototype tamarillo honey jam composed of tamarillo fruits and honey will be developed. The ingredients were chosen based on their known nutritional and medicinal value and availability.

Ingredients for tamarillo honey jam;

Honey

Honey is not only an intensified mixture of two monosaccharides; glucose and fructose but also rich in components such trace elements, proteins, vitamins, organic acids, flavonoids, phenolic acids, and enzymes. It possesses various properties of benefit to human health. It has antioxidants, antimicrobials, anti-inflammatory, antidepressant, and hepatoprotective and immunomodulation activity (Keskin *et al.*, 2021). Honey can impede the growth of pathogens like *Bacillus subtilis, Escherichia coli* and *Pseudomonas aeruginosa* (Ferreira *et al*, 2019). Honey also showed success against *Salmonella enterica Typhi* and *Pseudomonas aeruginosa* which are human health important bacteria in vitro studies. It has also demonstrated antiviral properties and in particular Manuka honey which was found to be useful in inhibiting the influenza virus activity. Influenza virus which is a threat to human health both among children and adults and infectious respiratory disease transmitted by coughing and sneezing through air (Ferreira *et al*, 2019). According to (Ulloa, 2010), moderate consumption of honey does not lead to hyperglycemia due to the slow process of conversion of levulose. This allows quality time for elimination of sugar by the human body. This proves why honey can be incorporated in the stabilized diabetic patients' diet posing a lesser risk than refined table sugar. It was

also used as a preservative, which acts as food additives used in food to increase the quality and lengthen the shelf life.

Table 2.1 demonstrates the Chemical Composition of Honey and Sugar in 100g

Table 2.1: *Chemical Composition of Honey and Sugar*

Component	Honey	Sugar
Glycemic index	58	60
Calories	300 Kcal	387 Kcal
Sugars	80.0 g	99.9 g
Lipids	0.02 g	—
Protein	0.3 g	—
Calcium	6.0 mg	1.0 mg
Iron	0.42 mg	0.01 mg
Magnesium	2.0 mg	—
Phosphorus	4.0 mg	—
Zinc	0.22 mg	—
Potassium	52.0 mg	2.0 mg
Vitamin C	0.5 mg	—
Vitamin B2	0.038 mg	0.019 mg
Vitamin B3	0.121 mg	___
Vitamin B5	0.068 mg	___
Vitamin B6	0.024 mg	___
Vitamin B9	2.0 µg	___
Water	17.0	0.03

Source: (1) Bobiş et.al, (2018)

2.2 Origin, Chemical and Nutritional composition of Tamarillo

Tamarillo (*Cyphomandra betacea*) which is native of Andean regions of South America, Peru, Ecuador, Argentina and Bolivia is a small tree, rather shrub in the flowering plant family Solanaceae (the nightshade family) (Wang *et al*., 2020). It further spread to the subtropical and tropical parts of south and Central America, that is; Brazil, Mexico and West Indies. Later was taken to Azores, South Europe and Madeira. In late 19th century, the seeds were sent to the British colonies and today are grown in Kenya, Southern Europe, USA, Brazil, Sri Lanka, Australia, India, among other places, New Zealand being the main producing and exporting country that highly values tamarillo (Guimarães *et al*., 1996). Tamarillo possess properties that are increasing its demand in the market which include; a high antioxidant activity, contents of carotenoids, ascorbic acid, Vitamin B6 and provitamin A (Acosta-Quezada *et al*., 2016). Tamarillo has been commercially cultivated in New Zealand, Columbia, Australia and California (USA). It possesses various other names including; tree tomato, tomate de yuca, tomate andino, tamamoro, tomate serrano, sachatomate, berenjena, and tomate de arbol in South America (Anon (2018).

Tamarillo is a subtropical fruit that produces fruit throughout the year with its peak seasons in autumn or late summer. It grows to a height of 2-4 meters and within the first 12-18 months, it starts bearing up to 3-4 years where it climaxes production maintaining it up to 6-8 years (Acosta-Quezada *et al*., 2016). It has a distinctive acidic flavor, an attractive deep skin and flesh. The tamarillo tree has a life expectancy of 5-12 years with perennial leaves and strong musky smell. Fruits contain many seeds slightly larger than those of tomatoes. Mostly characterized by the skin types, that is red, yellow, and purple.

It has naturally grown in places with rainfall between 600and 4000 mm, average annual temperatures of 15 up to 250C, and a soil pH of 5 to 8.5 (Osorio *et al.*, 2012).

Unfortunately, tamarillo is an underutilized, sustainable fruit crop with great potential for value-added products preparations such as salads, sauces, soups, jellies, jams, ice creams. It has significant amounts of bioactive components like anthocyanin's, carotenoids and flavonoids (Osorio *et al.*, 2012). Tamarillo fruit has a low fat content and low calories. It is a source of soluble sugars, proteins, dietary fibre, minerals like iron, zinc, phosphorus, Magnesium, potassium, Calcium and copper and Vitamins like C, A, E and B6 (Wang *et al.*, 2020). Amounts of vitamins B_6, C and E and of trace elements such as iron, magnesium, copper and potassium present in one tamarillo fruit may supply over 5% of the RDI (recommended daily intake) of these nutrients (Lister *et al*., 2005). Its carbohydrates content consists of low levels of sugars (fructose, glucose and sucrose) compared to other tropical fruits with approximately 3% of fiber (Boyes & Strübi, 1997). Vitamin A is playing an important role in the diets and taking it in low quantities can reduce one's ability to fight infections making it an essential nutrient for pre-school children. It can be obtained naturally in two forms as either pre-formed as retinol and as pro-vitamin A (carotenoids) (Maqsood *et al*., 2004 and Mayo-Wilson *et al*., 2011). According to dietary supplement fact sheet, among the key important functions of Vitamin A is optimal functioning of the immune system, vision, growth and bone development. It is stated that ascorbic acid contributes to maintaining the normal function of the immune system, contributes to proper collagen formation, necessary for normal functioning of blood vessels, the function of bones, cartilage, gums, skin, and teeth, and contributes to the protection of cells from oxidative stress.

Table 2.2: *Chemical Composition of Tamarillo*

Parameters	Value	Percentage (%)
Total soluble solids	10-13.5 ºBx	4.8
Water	(81-87) %	83.6
Fat	0.05-1.28 mg/100g	0.8
Total acidity	1.0-2.4 mg/100 g	0.8
Protein	1.5-2.5 g	0.52
Calcium	3.9-11.3 mg/100 g	9.51

Source: (1) Bakshi et al. (2016) Source: (2) Nallakurumban et al. (2015)

Figure 2.0.3 *A photo of tamarillo fruit*

Table 2.3. *Nutrition value per 100 g. of Tamarillo (Tamarillos (Cyphomnadra betacea), red, fresh, flesh and seeds, raw)*

Nutrient	Value	Percentage % of RDA
Energy	31 Kcal	1.5
Carbohydrates	3.8 g	3
Protein	2 g	4
Total Fat	0.36 g	1.5
Cholesterol	0 mg	0
Dietary Fiber	3.3 g	9
	Vitamins	
Folates	4 µg	1
Niacin	0.271 mg	1.5%
Pyridoxine	0.198 mg	15%
Thiamin	0.043 mg	3.5%
Vitamin A	630 IU (189.17 µg)	21%
Vitamin C	29.8 mg	50%
Vitamin E	2.09 mg	14%
	Electrolytes	
Sodium	1.44 mg	<1%
Potassium	321 mg	7%
	Minerals	
Calcium	10.7 mg	1%
Copper	0.051 mg	5.5%
Iron	0.57 mg	7%
Magnesium	20.6 mg	5%
Manganese	114 µg	5%
Phosphorus	38.9 mg	5.5%
Selenium	0.1 µg	<1%
Zinc	0.15 mg	1%
	Phyto-nutrients	
Folates	4 µg	1%
Niacin	0.271 mg	1.5%

Source: Pdf-New Zealand Food Composition Database (Athar et al. 2003)

2.3 Physical characterization and functional properties of tamarillo-based products.

According to Mertz *et al*. (2010), the carotenoids levels of tamarillo were determined by high-performance liquid chromatography-photodiode array detection/mass spectrometry (HPLC-PDA/MS). Among them, trans-β-cryptoxanthin esters and all-trans-β-carotene were the major carotenoids of tamarillo. Xanthophylls were found esterified with palmitic and myristic acids. The study looked at the changes in carotenoid and vitamin C contents

after thermal pasteurization of degassed and non-degassed tomato tree nectars. According to the study, Zeaxanthin esters were the less thermo-labile carotenoids and its degradation was not significantly influenced by dissolved oxygen level. However, thermal treatment induced 5, 8-epoxidation and cis-isomerization. Ascorbic acid (Vitamin C) retention was total under degassed conditions while losses of dehydroascorbic acid were not affected by the initial level of dissolved oxygen.

Hydrocolloids also form very important functional property of tamarillo. According to a study on functional and Preliminary Characterization of Hydrocolloid from Tamarillo (Solanum betaceum Cav.) Puree, it was established that, the extract from tamarillo puree consisted of 66.48% dietary fibre, 21.18% protein and 0.83% starch. The degree of esterification derived from FT-IR spectrum was 49.47%. The study found out monosaccharides like mannose, ribose, rhamnose, galacturonic acid, glucose, galactose, xylose and arabinose. Good oil-holding capacity (2.11g oil/g dry sample), emulsifying activity (84.74%) and emulsion stability (94%) propose its possible application as a plant-based food emulsifier. The study demonstrated a foaming capacity of 32.19% which is unique for a plant derived hydrocolloid. Interestingly, it showed better foam stabilization (79.36% of initial foam volume) characteristics than bovine gelatin (11.01%) through 2 hours from the formation of the foam. These findings suggest that water extracted tamarillo hydrocolloid can be utilized as a low methoxyl pectin in reduced sugar products, milk gels and desserts Gannasin *et al,* (2012). According to Rickman *et al*, (2007) the authors pointed out that the effects of processing, storage, and cooking are highly variable by commodity. The initial thermal treatment of processed products can cause loss of water-soluble and oxygen-labile nutrients such as vitamin C and B vitamins. However,

these nutrients are relatively stable during subsequent canned storage owing to the lack of oxygen. Frozen products, in turn, lose fewer nutrients initially because of the short heating time in blanching, but they lose more nutrients during storage owing to oxidation. The general conclusion of this review was that while canned foods are often perceived as less nutritious than fresh or frozen products, the research reveals that this is not always true.

2.4 Sensory evaluation and food acceptability

Sensory evaluation creates room for product testing and reduces cases of its failure and also an understanding of the consumer's product acceptability. Usually sensory science incorporates use of the five senses; touch, smell, sound, sight and taste to measure and evaluate individuals appeal to products (Rana *et al*., 2021). Foods usually before approval and acceptance in any community or group of people, it has to be tasted. People vary in their views based on certain foods and that in itself creates diversity and creates room for more food choices. Food acceptability is based on pleasure commonly referred to as hedonics since it is subjective measure. Food acceptability is influence by several factors based on its relationship to the environment which it is eaten from, the food itself and the individual who consumes it. Food is usually served in various contexts and times. This may influence ones mood and reaction towards it too. This explains other contributors to ones acceptance to food like; ones culture, context of food, physiological status, ones sensory properties of the food and previous exposure to that particular food and the expectations of it (Murray & Baxter, 2003). Every newly developed product goes through the process of consumer testing, acceptability, before being introduced to the market. Considering the adult versus the preschoolers, adults are more likely to understand and

answer the questions directly. Preschoolers based on their age are pre literate and needs assistance during the product administration (Popper & Kroll, 2011). The 9-point hedonic scale is the most widely used in measuring food acceptability and this research utilizes it since the results obtained by it are most informative (Stone *et al*., 2021). It has been adopted internationally by practitioners and scholars due to its ease of use and simplicity unlike paired preference methods which are strenuous (Cardello & Jaeger, 2010).

2.5 Nutrition indicators

Micronutrient deficiency leads to unrealized human potential and low economic productivity in a society. It also leads to increased mortality and morbidity rates, impaired physical and mental growth (Miller & Welch, 2013). Recent initiatives to combat malnutrition in all its forms has led to a decrease in micronutrient deficiencies. Increasing production and processing of micronutrient rich foods fruits inclusive, leads to a decline in malnutrition status of the population. Food based strategies have proved effective in promoting diversification and consumption of nutrient rich foods (FAO, 2011). Kenya's high rates of under nutrition are particularly due to poor maternal micronutrient status and consequent low birth weight (LBW), poor infant feeding practices, lack of access to adequate water and sanitation and safe hygiene practices, as well as malaria and HIV/AIDS (Shrimpton and Saldanha, 2011; KNBS & ICF Macro, 2010). Major micronutrient deficiencies include iodine deficiency disorder, iron deficiency anemia, and vitamin A and zinc deficiency, with high rates among young children. Nutrition assessment will also be done looking keenly at the clinical indicators of micronutrient deficiencies during administering the jams. Insufficient "awareness and knowledge on nutritionally adequate diets and limited resource allocation and capacity to support the

implementation of comprehensive nutrition programs" (Republic of Kenya 2008 & 11) are additional factors. In the study, the age, weight, height and MUAC of children will be recorded at the beginning of the study and will help in drawing conclusions of the study but not form part of the data to be collected. The major anthropometric indicators used to assess children's nutritional status are height-for-age, weight-for-height, and weight-for-age and MUAC (mid – upper arm circumference) (WHO, 2006). However, weight-for-age reflects two distinct components which are typically unrelated to each other, height-for-age and weight-for-height has been recognized that height-for-age is the appropriate indicator of long-term or chronic malnutrition and weight-for-height is the appropriate indicator of short-term or acute Malnutrition (WHO, 2006).

CHAPTER THREE

MATERIALS AND METHODS

3.0 Introduction

This chapter presents the research design that was used by the researcher in developing prototype tamarillo honey jam, determining nutrient composition of tamarillo honey jam and determining the acceptability of tamarillo honey jam among preschoolers and adults. It discusses the study setting, study design, study population, sample size determination, sampling procedure, data collection, analysis and presentation, validity and reliability of the instruments, and ethical and logistical considerations.

3.1 Study area

The study was conducted in Lurambi, Sub County, Kakamega County. Kakamega County is located in Western part of Kenya thirty kilometers North of the equator and about 46 Kilometers from Kisumu City. As per 2019 census, it had a total population of 1,867,579 people, with 897,133 males, 970,406 females and 40 intersex persons. It has a uniform rainfall distribution throughout the year. The temperatures in most areas of the county ranges from 18 degrees to 29 degrees. Agriculture is the main economic activity in Kakamega County. 61% of population engage in livestock and crop farming.

County is subdivided into twelve sub counties namely: Butere, Ikolomani, Khwisero, Likuyani, Lugari, Lurambi, Mumias East, Matungu, Shinyalu, Navakholo, Mumias West and Malava. The County has a total of 60 wards. According to Kenya bureau of statistics report (2013) seventy percent of the residents in Kakamega county use improved water

and sanitation sources (UNICEF, 2016). Study area was purposively selected since there is scanty information on successful and sustainable food product innovations focusing on better and improved nutritional and health needs of Kakamega County occupants thus necessitating the need for this study.

Baseline surveys and field visits were carried out in Lurambi Sub County which is among the most populated with preschools. The county hosts a total of 1631 preschools with an enrolment of 105, 426 children as per the Ministry of Education Science and Technology report (2014). This represents 5.65% of its total population.

3.2 Study Design

This study adopted an experimental design for tamarillo honey jam development, descriptive cross-sectional design for analysis and acceptability tests. Qualitative and quantitative techniques for data collection were employed**.**

3.2.1 Study procedure

Collection of materials and Methods

The researcher conducted various field visits in Kakamega, Kitale and Eldoret to identify the red variety, ripe and ready for harvest tamarillo fruits used in the study. The researcher settled on (*Cyphomnadra betacea*) red tamarillo in colour since it was the most planted and consumed. A farm in Kitale was identified with ready fruits for harvesting since it was the most available in the three areas, which were closer to the study area. The choice of these fruits was guided by the popularity of the fruits and availability around the area.

The fruits were packaged in Kilograms of 2 to 6 in sealed boxes and transported by road to Kisumu KIRDI centre where they were signed in at the main entrance, received at the processing unit and weighed. They were sorted and graded then taken to the processing. Raw honey was identified and sourced from a farmer in Marigat, Baringo County. The honey was packaged in sealed airtight containers of 5 Kgs and sealed in boxes. It was then transported by road to Kisumu KIRDI centre for processing. Pectin and preservatives were purchased from Nairobi City, Kenya. Laboratory experimental analysis; post-harvest and storage operations, safety analysis and the shelf-life stability of Tamarillo honey jam was observed during processing at KIRDI. Tamarillo honey jam was then formulated followed by sensory evaluation and consumer acceptability studies.

3.3 Developing tamarillo honey jam

Tamarillo jam was produced at (KIRDI), Kisumu. Tamarillo jam adopted the following mixing ratio in table 3.1. Quantity was increased based on production level.

Table 3.1 *Tamarillo honey jam mixing ratios*

Tamarillo honey jam mixing ratios						
	1st trial		2nd trial		3rd trial	
Raw materials	**Amount (Kgs)**	**(%) Pulp**	**Amount (kgs)**	**(%) Pulp**	**Amount (kgs)**	**(%) Pulp**
Fruit pulp	4.3	57.01	4.3	58.75	4.3	64.93
Honey	3.23	42.82	2.8	38.29	2.15	32.45
Pectin	0	0	0.215	2.94	0.172	2.59
Citric acid	0.013	0.17	0	0	0	0
Preservatives	0	0	0.002	0.02	0.002	0.03
Total	**7.543**	**100**	**7.317**	**100**	**6.624**	**100**
Parameters	**1st Test**	**2nd Test (before packaging)**	**1st Test**	**2nd Test (before packaging)**	**1st Test**	**2nd Test (before packaging)**
Brix (°Bx)	53	68	63	70	65	73
Acidity		1.2		1.3		3
Temperature (^{0}C)	95	70	98	65	99	50

The researcher mixed and tested various ratios in developing the product and finally settled on one ratio which met the suitability index as illustrated in Figure 3.1. Mature and ripe tamarillo fruits were obtained from the farm together with raw honey. The researcher mixed 64.93% (4.3 kg) of fruit pulp, 32.45% (2.15 kg) of honey, 2.59% (0.172 kg) of pectin and 0.03% (0.002 kg) of the preservatives for the final product as shown in table 3.1.

3.3.1 Preparation of fruit pulp

The raw materials once received at the processing unit, were measured using a weighing scale, the weights recorded and set aside as illustrated in the table below. The fruits were sorted, washed and the outer cover peeled off. The pulp was then blended to reduce the

cooking time of the pulp to preserve the nutrients and separated from the seeds by sieving. The pulp was then cooked at 95°C.

3.3.2 Addition of pectin, honey and preservatives

After 10 minutes, Pectin followed by honey was added by constantly stirring under a moderate fire, previously establishing the water-honey ratio for Brix grades required by the product for a maximum of 60 seconds at 80°C during the cooking process. Potassium sorbet and/or sodium benzoate were added and stirred to mix uniformly before being left to cool and set.

Production process

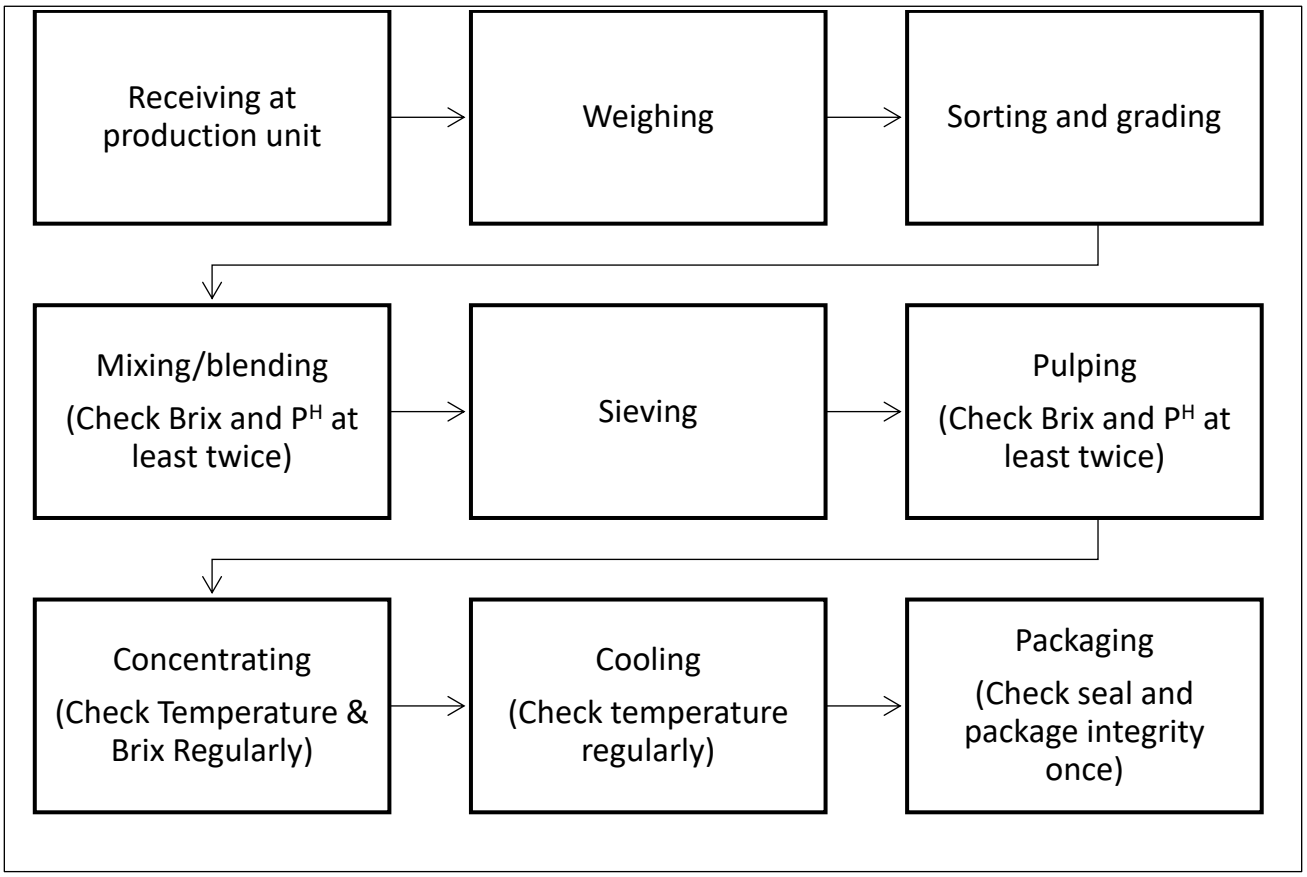


Figure 3.0.1 *Flowchart process for tamarillo jam -adapted and modified from (FAO, 2008)*

3.3.3 Tamarillo honey jam packaging

The jam was then packaged in pre-sterilized food grade containers with final weight of 85g, 250g and 500g and sealed at 50^0C to minimize possible chances of microbial growth as illustrated in the Figure 3.1.

Figure 3.2 *A photo of packaged and labelled tamarillo honey jam*

3.3.4 Product costing

With a fully developed product, the researcher calculated the total cost of expenses to determine the product pricing as shown in Table 3.2

Table 3.2 *Tamarillo honey jam costing and pricing*

CLAZEE ENTERPRISE			
		Tamarillo honey jam	
Ingredient/ Input	**Unit of measure**	**Pieces/250g**	**cost**
preservatives	Grams	10.30	70.30
honey	Grams	82.00	12.00
Tamarillo	Grams	164.00	24.00
packaging containers	pieces	1.00	20.00
Label	pieces	1.00	5.00
Direct salary			6.60
Transport			20.00
Rent		0.00	0.00
Electricity		0.00	0.00
Water		0.00	0.00
Direct Labour		0.00	0.00
Total Direct Cost		**258.30**	**157.90**
Desired Markup %		***60%***	***60%***
Desired Markup		154.98	94.74
Reco Distributor SP		**413.28**	**252.64**
Actual Distributor SP		0.00	0.00
Delta		*-413.28*	*-252.64*
RD Markup		0.00	0.00
RD Markup %		*0%*	*0%*
RRP			**0.00**
Actual Markup		*-100%*	*-100%*

3.3.4 Product acceptability test

A group of five trained panelists from KIRDI evaluated the samples of the tamarillo honey jam after the first second and final trial. The panelists who were between ages (18-60) were recruited based on no known allergies to tamarillo fruits and honey. They consisted food scientists, student on internship and food lab technologist. The panelists had prior experience in sensory tests at the institution. The samples of 85g each were served at room

temperature with a scoop for testing. The panelists were instructed to rinse their mouths before textural attributes. They examined the firmness, colour and appearance, texture, fluidity and smell. The panelists scooped with their spoons and tested the product based on 3 point acceptability scale (3=tastes great, 2=acceptable, 1=unacceptable) and further discussed the way forward.

3.4 Laboratory Analysis

3.4.1 Tamarillo honey jam safety analysis

A sample of three packaged tamarillo honey jam containers of the same size, type and style packed under similar conditions and handled as a single unit of trade was taken to KEBS for analysis of microbiological limit of yeasts and moulds, salmonella and Escherichia coli according to the law of Kenya. The colony forming units (CFU) of the yeasts and moulds was counted using the standard plate count method.

3.4.2 Mineral Composition

The mineral content was analysed using atomic absorption spectrophotometry (AAS). 0.5g of developed jam sample was put in a conical flask, added 10ml of nitric acid (HNO_3). The mixture was then be heated on a plate at 70-80^{0}C and later allowed to cool. 2ml of Hydrogen Peroxide and 5ml nitric acid was added and mixture heated again. The mixture was transferred to 100ml volumetric flask and brought to volume with double distilled water (Hitachi model A-1800). The solution was used for minerals analysis

which was determined by AAS (Gupta, 1999). Quantification was done by reference standard solutions of specific minerals.

3.4.3 Proximate Composition

To determine their proximate composition, the macromolecules that is protein, crude fibre, fat, carbohydrates, ash and moisture levels and crude fibre was determined by (AOAC) methods of analysis.

3.4.4 Crude protein

Crude Protein was determined using the AOAC 2001.11. >1g of a sample of tamarillo honey jam was digested in Sulphuric Acid (H_2SO_4), to convert the protein to Ammonium Sulphate ($(NH_4)_2SO_4$) at a boiling point which was accelerated by addition of Potassium Sulphate (K_2SO_4) and Copper (Cu) catalyst. Water was added automatically to the digest to avoid mixing the concentrated alkali with concentrated acid to prevent it from solidifying. To neutralise the acid and make the digest basic, concentrated Sodium Hydroxide (NaOH) was added. Ammonia (NH_3) is liberated during the process, the liberated NH_3 was distilled into a Boric Acid (H_3BO_3) solution and titrated with standardized Hydrochloric Acid (HCL) to a colorimetric endpoint. The endpoint detection system was used in standardization of the analyte “N” which is the crude Protein. The crude protein was calculated as the percentage (%) of Kjeldahl analyte (N) multiplied with the factor (F= 6.25).

3.4.5 Moisture Content

Moisture content; 10g of sample tamarillo honey jam was weighed and put in a clean dish and recorded as (W1). The sample was transferred to the oven at 107^0C for 6 hours. Temperature was monitored using the external temperature meter on hourly basis while recording on a paper. The sample was then cooled in desiccators for 15 minutes and recorded as (W2). The moisture % was calculated as the difference of (W1-W2) multiplied by 100.

3.4.6 Ash content

The ash content; a clean crucible was weighed and value recorded as (W1). 10g of tamarillo honey jam was weighed and placed in a clean crucible and denoted as (W0). The sample and crucible were transferred to the muffle furnace at 525+250C for two hours to allow the sample reduce to ash. It was then cooled in desiccators for 15 minutes then weighed and denoted as (W2). The % total ash content was calculated as the difference in (W2-W1) multiplied by 100.

3.4.7 Crude fibre content

The crude fibre content; 2g of sample tamarillo honey jam was weighed and recorded as (W0) and transferred to 100ml beaker. 0.13M of H_2SO_4 acid digest was poured over the sample for 30 minutes. It was allowed to cool and the acid was filtered out with a filter cloth and washed with 300ml of hot distilled water. The residue was filtered with 30ml of

acetone and washed with di ethyl ether. The digest was transferred to beaker and 150ml of 0.23M of KOH was added and boiled for 30 minutes and later allowed to cool. The KOH solution was filtered out with a filter cloth. The digest was washed with hot water followed with 30ml of di ethyl ether then transferred to a crucible and dried at 130^0C for 2 hours. The residue digest was allowed to cool in the desiccator then weighed and weight recorded as (W1). The digest was transferred in a furnace and let to ash for 45 minutes. It was then allowed to cool in the desiccator then weighed and weight denoted as (W2). The crude fibre percentage was then calculated by getting the difference in (W1-W2) then multiplied by 100.

3.4.8 Carbohydrate content

Total carbohydrate content was obtained by calculating the difference of a total percentages of protein, fat, ash, moisture and alcohol which is 0 from 100%.

3.4.9 Sugar content

Sugar content comprised of reducing and non-reducing sugars; 10-50g of tamarillo honey jam was weighed (W) and transferred to 500ml volumetric flask. 100ml of water was added and neutralised with 10ml of NaOH solution to phenolphthalein end point. 10 ml of neutral lead acetate solution was added then shaken and left to stand for10 minutes. Potassium oxalate solution was added in small amounts until there was no further precipitation. The solution (V_2) was filtered and then transferred to a 50 ml burette having an off-set tip. For preliminary titration, 5 ml of Fehling A and B solutions were pipetted

to a 250ml conical flask. 10 ml of water and a few glass beads were added and mixed. The sugar solution from the burette was dispensed and the solution heated to boiling. 3 drops of methylene blue indicator were added. The sugar solution was added drop wise until the blue colour disappeared to a brick red end point. The concentration of the sample solution ensured the titre value was between 15 to 50ml. A total boiling period of 3 minutes was maintained and the titre value denoted. Final titration involved 5 ml of Fehling A and B solutions each pipetted into a conical flask. A sample solution of about 0.05 to 1.0 ml less than the titre value of preliminary titration was added and the flask heated to boiling. 3 drops of methylene blue indicator were added. The titration was completed within 1 minute by adding 2 to 3 drops of the sugar solution at a time until the indicator was decolourized. At end point, the boiling liquid assumed the brick red colour and the titre value was denoted as (V_3). The titration was performed in duplicate and the average taken. The calculation were as follows; based on the factor for Fehling's solution, (V_3) ml sample contains 0.0025 V1 g reducing sugar (as invert sugar). Therefore % of reducing sugars is;

$$\text{Therefore, \% Reducing Sugars in the sample} = \frac{0.0025 \times V_1 \times V_2 \times 100}{V_3 \times W}$$

$$= \frac{0.25 \times V_1 \times V_2}{V_3 \times W} = X\ \%$$

The total reducing sugars; an aliquot of 50 ml of the clarified, de-leaded filtrate was pipetted to a 100 ml volumetric flask. 5ml of concentrated HCL was added and allowed

to stand at room temperature for 24 hours. It was later neutralized with NaOH solution followed by 0.1N NaOH using phenolphthalein as end point indicator. It was made up to volume (V_4) and transferred to 50 ml burette having an off-set tip. The titration against Fehling's solution was performed similar to the reducing sugars described above and the total sugars were determined as invert sugars. Based on the factor for Fehling's solution total reducing sugars in V_4 ml = 0.0025 × V_1 g. As 50 ml of the clarified and de-leaded solution is diluted twice (50 ml to 100 ml) after hydrolysis, dilution volume of the sample = (2 × V_2).

$$\text{Therefore, \% Total reducing sugars (As invert sugars)} = \frac{0.0025 \times V1 \times 2 \times V2 \times 100}{V4 \times W}$$

$$= \frac{0.5 \times V1 \times V2}{V4 \times W} = Y\ \%$$

3.4.10 Fat- and water-soluble vitamins composition

Sample of tamarillo honey jam was analyzed for Beta - carotene and Vitamin C. Beta carotene was analysed using UV Spectrophotometer and Column Chromatography by acetone and petroleum ether extraction methods by (Rodriguez- Amaya & Kimura, 2004). 2 g of tamarillo honey jam was weighed, placed in a mortar with 10ml of acetone. They will be thoroughly mixed and acetone extract transferred to 100ml volumetric flask. The

residue was extracted continuously with acetone until it gave no colour. 25ml of extract was evaporated using rotary evaporator. The residue was dissolved with 10ml petroleum ether and the solution introduced to HPLC column. The beta carotene elute was collected in a flask and was made to a volume of 25ml with petroleum ether. The absorbance was read at 440nm in a UV-Vis spectrophotometer (Shimadzu model UV – 1601 PC, Kyoto, Japan).

Reverse - phase HPLC method by (Ekinci & Kadakal, 2005) modified from (Takaichi, 2000) was used in analyzing water soluble vitamins like; Vitamin C and B Vitamins. 20 ml distilled water was added to 5g of the sample. The mixture was homogenized using a homogenizer for 1 minute at a medium speed. The homogenized sample will be centrifuged for 10 minutes at 14×10^3g. The stationary phase was flushed with 10ml water and 10ml methanol at a Ph. of 4.2 to activate it. The vitamin samples were separated using SPE C18 cartridges and eluted with 10ml methanol. Elutes were evaporated in the rotary vacuum evaporator and vitamins re dissolved in mobile phase. A total of about 20 ul was injected in the HPLC column. The column elute was monitored with a photodiode - array detector at the specified reference vitamin standard.

3.5 Study population for acceptability studies

The study population for this study included all the preschool children, parents and teachers within Lurambi, sub county of Kakamega. Participants were randomly selected for tamarillo honey jam acceptability test. The researcher included the participants between the ages of 4-5 years in the study. The parents of the study participants who consented were randomly selected to participate in the study.

3.5.1 Inclusion criteria

i. This study included all children (4-5) years who were actively attending preschool within Lurambi, Sub County of Kakamega.
ii. The study also included adults (Parents and teachers) (25-60) years of age within Lurambi, Sub County of Kakamega.
iii. It included only children whose parents had consented.
iv. The study was limited to Lurambi, Sub County of Kakamega.

3.5.2 Exclusion criteria

i. The study excluded all participants whose parents denied consent.
ii. It also excluded children outside the age bracket of (4-5) years and outside Lurambi, Sub County of Kakamega
iii. All adults (parents and teachers) outside the age of (25-60) years and non-residents of Lurambi, Sub County of Kakamega.
iv. The study excluded children and adults (parents and teachers) with health issues.

3.6 Sampling procedure

This study utilized multi-stage sampling strategy in selection of the study area. Kakamega County was purposively selected as the geographical area of study. There is scanty information on successful and sustainable food product innovations focusing on better and improved nutritional and health needs of Kakamega County occupants thus necessitating the need for this study. Lurambi Sub County was purposively selected

followed by simple random sampling of the preschools where the actual study was conducted.

3.6.1 Sample size determination

For the children (4-5) years, sample size calculation was based on the total enrolment of preschool children in Kakamega County as per the Ministry of Education Science and Technology report (2014). Fisher's *et al* (1991) formula was used to calculate the sample size at 95% significance level as follows

$$n = \frac{Z^2 Pq}{d^2}$$

Where;

n is the desired sample size (if the targeted population is greater than 10,000)

Z is the critical value associated with level of significance at 95%

P is proportion of target population estimated to have a particular characteristic.

P, the prevalence estimate for preschool children enrolment in Kakamega County according to ministry of education Kakamega County estimated at 5.65%

q is the population lacking the feature to be measured (1- 0.0565) = 0.9435

d is the margin of error i.e., 5%=0.05.

q=1-p

$n=1.96^2 \times p\ (1-p) \div d^2$ = sample size required

$n = 1.96^2 \times (0.0565)\ (0.9435) \div 0.05^2$

= 82 preschool children

Considering adding 10% design effect, the total study population was 82+ 10% = 90 preschool children. According to Mugenda (1999), based on the obtained sample, a sample size of between 10% and 30% is a good representation of the target population and hence the 30% was adequate for sampling. Each child in the preschools measuring up to the inclusion criteria of this study was randomly selected to participate. The selection criteria proceeded till the desired sample size was achieved in each preschool.

Purposive sampling was used in selecting the parents and teachers arriving at (n= (6-10) Since the actual number of participants preferred for a focus group session is 6-10 and the level of analysis is based on the actual number of participants (Klagge *et.al,* 2018). The groups consisted and were not limited to of 6 adults (Parents and teachers) (25-60) years with both females and males in the selected 7 preschools based on their availability.

3.7 Data Collection Instruments

3.7.1 Focus Group Interview Guide

The Focus Group Discussion (FGD) guide for adults(Parents and teachers) (25-60) years had a list of stipulated questions that were asked by the researcher as indicated in Appendix (II). Focus group interviews have been proved effective and of help in development of evaluative frameworks for assessing individual's needs. They are

essential in exploring and building on the research questions (Banning, 2005). The researcher employed the above qualitative data technique in gathering sensory evaluation information on smell, appearance/colour, mouth feel, taste, fluidity and general acceptance. The selection criterion was based entirely on the researcher and influenced by the group needed for the research. This was conducted after administration of tamarillo honey jam samples of 85g with scooping spoons to the parents and teachers in the 7 selected schools who were encouraged to participate freely. The discussions lasted a period of 50 minutes. The researcher sought responses on; How familiar they were with the jam, what are the things they like and do not like about the jam, what would most likely influence them to buy the jam, if there is anything to be improved, what would that be and would they recommend it to others. The participants gave feedback based on the sensory evaluation information and general acceptance of the tamarillo honey jam.

3.7.2 Child questionnaire Guide

This comprised various sections; personal information, demographic data, nutritional and clinical assessment data which were recorded by the researcher and research assistants. Also had the acceptability test which adopted the preference testing use of 9-point hedonic scale (Stone et al., 2021). The researcher and research assistants observed the preschoolers reactions while taking the jam and asked them relevant questions on the colour, taste, likes and dislikes as per the scale parameters and recorded the feedback of the preschoolers without any external influence.

Data Collection Methods

The researcher did a brief introduction of the study and created a rapport with the respondents and sought their consent. A face-to-face focus group discussion was conducted in a comfortable place and videos recorded for transcription purposes. Various data collection methods were used.

3.8 Data collection procedure

Data was collected during the normal school operation period in term one of 2022. It was collected during the morning hours before parade times, during long breaks and lunch breaks. Data collection was done within 7 working days in all the 7 schools. The researcher collected the data with the help of the research assistants. The researcher delivered the consent letters and introductory letters one week prior to the data collection in the respective schools; in Lurambi sub-county which were; Mahiakalo Primary, Fesbeth Academy, Blessed Nalic Academy, Bondeni Primary, Nabongo Primary, Lurambi Primary and Kakamega primary. Data collection was done on preschoolers whose parents had consented and excluded those whose parents declined.

3.8.1 Focus Group Discussions

It involved inviting parents and teachers aged (25-60)years who participated in the study Focus Group Discussion based on the current opportunity in terms of their access, location, time and willingness (Whitehead & Whitehead, 2016).

3.8.2 Child Questionnaires

The nine point hedonic scale was used to establish sensory parameters of the tamarillo honey jam. The 9-point hedonic scale is the most widely used in measuring food acceptability. The scale presentation ranged from like extremely to dislike extremely. The parameters used in sensory evaluation were; smell, appearance/colour, mouth feel, taste, fluidity and general acceptance.

Anthropometric data

The below data was collected to inform on the nutritional status of the children participating in the study but was not meant to influence outcome of the data. It helped in drawing conclusions of the present research. WHO (2006) standards of anthropometric data collection were used in this study to collect data on the nutrition status. The correct age of the child was confirmed in the child's birth certificate brought by the parent. The age of the child helped in counter checking the age inclusion criteria. Height, weight and MUAC measurements of the children were taken twice and averaged by summing up and dividing by two and recorded in the questionnaire. The recorded measurements were used to compute the indices of Weight for Age Z-scores (WAZ), Height for Age Z-scores (HAZ) Z-scores.

Weight measurement Weighing scales were calibrated first before taking any weight for each child. Weight of children aged (4-5) years who are able to stand on their own, were measured using a SECA digital weighing scale. Two weight measurements were taken for each child with minimal clothing and with no shoes and they were averaged. The weight was measured to the nearest 0.10 kilograms.

Height/length measurement Height of children (4-5) years were measured using a vertical wooden height board by placing the child on the measuring board, and child standing upright in the middle of board. The child was standing in an anatomical position with the back of the head, shoulders, buttocks, back of knees and heels touching the board. Two measurements were taken for each child with minimal clothing and with no shoes and they were averaged by summing up and dividing by two. All heights were measured to the nearest 0.01 centimeters.

MUAC measurement All MUAC tapes were sterilized before taking each child's measurement. The tip of the child's shoulder was located using fingers. The child's elbow was bent to make the right angle. The tape was placed at zero. The number at the tip of the elbow was read to the nearest centimeter. It was divided by two to get the mid-point. The midpoint was marked using a pen on the arm. The child's arm was wrapped using a tape around the mid- point. The readings were taken twice, averaged and recorded to the nearest 0.1 centimeters (WHO, 2006).

3.9 Recruitment and training of research assistants

Two research assistants who qualified and were licensed nutritionists were selected and trained accordingly. The recruitment template entailed language proficiency that is; English and Swahili with background and up to date knowledge of the area of study. The training ran for two days consecutively on the data collections tools and data collection process. The data collection tools were sent to them for familiarization. The training program included; introduction and objectives of the study; overview of the content and comprehension of each item on the questionnaire, and observation guide; interviewing

skills; research ethics and code of conduct. A practical demonstration of the pretest was done through physical administration of the questionnaires. Screening and checking for completeness were done to enhance understanding and mastery of the exercise. The training was concluded with the preparation of a work plan for carrying out the study.

3.10 Validity

Validity of an instrument refers to how well the instrument measures what is supposed to measure according to Bolorinwa (2015) the usual procedure of assessing the content validity of a measure is to use a professional or an expert in a particular field. Validity of this research instruments was ensured by a panel of 5 competent researchers in this field of nutrition at Masinde Muliro University of science and technology and the feedback was put into consideration.

The researcher and the research assistants did a pre-test of the questionnaires in Lurambi sub-county in 1 purposively selected preschools, to check the clarity and specificity of the questionnaires if they were in congruence with the study objectives and it was not included in the main study. About thirty percent of the study sample size (90) formed the sample size (27) for pre-test. Subjects for pretesting meeting the inclusion criteria were purposively selected. The study was explained to the respondents and informed consent obtained. Each research assistant was assigned fourteen questionnaires. They provided feedback on their experience in collecting the data together with the researcher. The data obtained was analyzed and informed on the modification of the research data collection tools.

For instance, on the focus group discussions, the questions were reframed to address the sensory attributes unlike previously where they sought to only understand the product. The adults (Parents and teachers) (25-60) years also suggested utilizing the early morning hours before reporting to their duty stations which was considered during actual data collection. There was a suggestion to include the statistics in terms of weight and gender representation in the focus group guide. The researcher worked alongside the research assistants for supervision and quality checks. All the questionnaires were scanned for completeness and proposed suggestions incorporated to improve the content and comprehension of the tools, creating the basis of validating the data collection tools for this study.

3.11 Data analysis

Quantitative data was keyed into Excel 2013 before being loaded to Statistical Package for Social Sciences (SPSS) version 26 data sheets for descriptive analysis. Charts and tables were generated. In qualitative analysis NVIVO Version 20 software was used. The focus group interviews were recorded and the videos and audios were transcribed in NVIVO and evaluated for the relevant codes. The qualitative data for adults' perceptions were drawn from the objective of the study which sought to determine its acceptability. This was further broken down into major codes of familiarity with the product, taste and texture, smell, likes and dislikes of the product and their recommendations among the adults.

Table 3.3 *Data analysis table*

OBJECTIVES	STATISTICAL SOFTWARE USED	STATISTICAL TOOL/ ANALYSIS	DATA PRESENTATION
1.	Excel 2016	Thematic analysis	Themes Tables, charts and graphs
2.	Excel 2016	Descriptive analysis	Tables
3.	Excel 2016	Descriptive analysis	Tables
4.	Excel 2016 SPSS Version 20 NVIVO Software	Descriptive analysis - Frequencies and percentages Transcripts	Tables, charts and graphs

3.12 Logistical and ethical considerations

Ethical review and approval to conduct the study was sought from Masinde Muliro University of Science and Technology Institutional Ethics and Review Committee with an Approval number, MMUST/IERC/028/2021. A Research Licence with licence number, NACOSTI/P/21/14247 was obtained from the National Commission for Science, Technology and Innovation (NACOSTI). KEBS certification was sought for safety analysis of tamarillo honey jam and permission from KIRDI for nutrient analysis. A clearance to conduct research in Kakamega County was obtained from Kakamega County Commissioners office. Permission was obtained from the local administration (Chiefs, Municipal managers, town managers). Written consent was also sought from the research participants and their caregivers. Information that was collected was kept securely and confidentiality was maintained. The identity of the respondents was kept confidential by

serializing the questionnaires. No harm was done to any participant and the procedures were non-invasive. The researcher explained to the participants the objective of the study. Participants who might have experienced allergic reactions were withdrawn from the study.

The following ethical considerations were upheld;

Autonomy

Informed consent and confidentiality affected the autonomy as follows;

Informed Consent

The researchers introduced themselves and clearly explained the objectives of the study to the respondents prior. An informed consent was sought from the respondent's parents before proceeding with the data collection without being coerced. The decision of the respondents to either consent or not was acceptable. The respondents signed the consent form once they allowed the researcher/research assistant collect data from them.

Confidentiality

The researcher assured the respondents on the confidentiality of the information obtained from them. To ensure anonymity and confidentiality, data pertaining the names of the respondents and next of kin was not be recorded and serial codes were assigned to each questionnaire to conceal identity of the respondent. All questionnaires were safely kept in lockable cupboards and data entered in a computer was encrypted with passwords for maximum confidentiality of the information.

Non- maleficence

As per the study no harm was done to the respondents since the Tamarillo honey jam provided was tested and certified for human consumption by Kenya Bureau of Standards (KEBS).

Beneficence

The data obtained was used for research purpose with the view of improving dietary practices, immunity and nutrition status through evidence-based information to practitioners. It will help immensely to advise the respondents on their diet and dietary intake. The respondents may not directly benefit from this study but the information obtained will be instrumental in informing policy makers on how best to plan and improve the quality of life.

Justice

This study picked fairly all respondents who met the criteria for selection and all data collected was analysed. During the study, all the respondents were treated equally regardless of the religion and social status in the community. There was no physical harm to the respondents as data collection methods were be non-invasive.

CHAPTER 4

RESULTS

4.0 Introduction

The findings of the study on development, nutrient composition and acceptability of tamarillo honey jam among preschools (4-5) years and adults (Parents and teachers) (25-60) years in Lurambi sub county, Kakamega are presented here. They seek to answer the research questions on tamarillo honey jam nutrient composition, safety and acceptability among preschoolers (4-5) years and adults (Parents and adults) (25-60) years.

4.1 Development of tamarillo honey jam.

The results revealed the composition of tamarillo honey jam at 64.93% (4.3 kg) of fruit pulp, 32.45% (2.15 kg) of honey, 2.59% (0.172 kg) of pectin and 0.03% (0.002 kg) of the preservatives (Potassium sorbet and/or sodium benzoate). The test parameters examined by panelists at the production stage and rated on the 3 point acceptability scale (3=tastes great, 2=acceptable, 1=unacceptable). The discussions revealed in the first trial the colour was unacceptable due to the amount of honey added, the taste was very sweet and the final product was not firm. In the second trial the taste was still sweeter and amount of honey needed to be reduced. The pectin was introduced to help in firmness of the product and preservatives included to increase shelf life since the product would develop moulds after two weeks without refrigerating. The final trial was acceptable among all the panelists before proceeding to the field for acceptability among preschoolers(4-5) years and adults (Parents and teachers) (25-60) years.

Table 4.1 *Panelists results*

Parameter	**1st trial**	**2nd trial**	**3rd trial**
Colour	unacceptable	Acceptable	Acceptable
Taste	unacceptable	unacceptable	Acceptable
Fluidity	unacceptable	unacceptable	Acceptable
Firmness	unacceptable	unacceptable	Acceptable
Smell	unacceptable	Acceptable	Acceptable

4.2 Analysis of proximate and micronutrient composition of developed tamarillo honey jam

The proximate results in table 4.1 revealed moisture content at 21.5% as per the ISO 6496 Test method. Crude protein at 0.1% which was tested as per the AOAC 2001.11. Fat content was at 0.36% according to AOAC 2003.05 method. Sugar content at 30.32%in line with Lane and Eynon method. Crude fibre using the ISO 6541 formula was at 0.02%. ISO 936 test showed total ash at 0.22% and carbohydrates at 77.82% according to FAO, 2003 method. The micronutrients levels were also determined using various test methods. AOAC 999.10 method revealed trace elements Zinc 0.03 mg/100g, Iron 0.08 mg/100g, Potassium 0.01 mg/100g, Sodium 1.09mg/100g and Magnesium 2.3 mg/100g. ISO 20633 method tested fat soluble vitamins A and E and found out Vitamin A 0.3 µg/100g and Vitamin E 0.2 µg/100g together with Vitamin C which is a water-soluble vitamin and

discovered 49.63 µg/100g. The B vitamins were also tested using the ISO 21470 and Vitamin B was 0.16 µg/100g in the developed tamarillo honey jam.

Table 4.2 *Proximate and some micronutrient composition of tamarillo honey jam*

Proximate and Micronutrients Test Results		
Parameters	**Amount percentage% per 100g**	**Test method**
Moisture content	21.5	ISO 6496
Crude protein	0.1	AOAC 2001.11
Fat content	0.36	AOAC 2003.05
Sugar content	30.32	Lane- Eynon
Crude fibre	0.02	ISO 6541
Total ash	0.22	ISO 936
Carbohydrates	77.8	FAO 2003
Trace elements	**mg/100g**	
Zinc	0.03	AOAC 999.10
Iron	0.08	AOAC 999.10
Potassium	0.01	AOAC 999.10
Sodium	1.09	AOAC 999.10
Magnesium	2.3	AOAC 999.10
VITAMINS	**µg/100g**	
Vitamin A	0.3	ISO 20633
Vitamin E	0.2	ISO 20633
Vitamin B	0.16	ISO 21470
Vitamin C	49.63	ISO 20633
Folate	0.00	ISO 21470

The serving size for tamarillo honey jam per sitting would be 2 tablespoons (30g) providing the following;

Table 4.3 *Amount per serving*

Nutrient content	**Amount**
Total kilocalories	94.3kcals
Carbohydrates	23.34
proteins	0.03
fats	0.11
Zinc	0.01mg
Iron	0.02mg
Potassium	0.003mg
Sodium	0.33mg
Magnesium	1mg
Vitamin A	0.1 µg
Vitamin E	0.1 µg
Vitamin B	0.04 µg
Vitamin C	15 µg

4.3 The microbiological limit of yeasts and moulds, salmonella, coliform and Escherichia coli, safety and quality standards of developed tamarillo honey jam

The researcher subjected the final tamarillo honey jam product on a laboratory test under the acceptance criteria and specification (KS EAS 947: 2019, Kenya Standard Specification for Jams, Jellies and Marmalades) against which it was tested. Table 4.4 displays the results findings;

Table 4.4*: Tamarillo honey jam safety analysis report*

Parameters	**Unit**	**Requirements**	**Results**	**Test methods**
Coliform	cfu/g	100Max	<10	ISO 4832
Escherichia coli,	cfu/g	Shall be Absent	Not detected	ISO 16649-2
Salmonella spp	per 25g	Shall be Absent	Not detected	ISO 6579-1
Yeasts and Moulds	cfu/g	100Max	<10	ISO 21527-2

4.4 Sensory attributes and acceptability of tamarillo honey jam on preschool children (4-5) years and adults (Parents and teachers) (25-60) years (25-60) years.

4.4.1 The demographic characteristics of respondents.

The current study sought to identify the reactions and responses of the research participants in the 7 randomly selected schools where actual data collection took place. The responses were in line with the data collection tools used as shown in the Appendices (I and II). With the research question of establishing the acceptability of the newly developed tamarillo honey jam, a focus group discussion was carried out on the adults (Parents and teachers) (25-60) years available and meeting the inclusion criteria.

The total number of parents and teachers who participated in the study were 48 with half the number being teachers (n=24) and the other half parents (n=24). In the age groups 12.5% (n=6) were between (25-34) years, 54.2% (n=26) between (35-44) years and 33.3% (n=16) between (45-54) years, Male were 25% (n=12) and female were 75% (n=36). The mean weight of all the participants (n=48) was 71.25Kgs. The teachers who took part in the study were college and university graduates. The parents consisted of business people, medical practitioners and farmers. Preschoolers who took part included both females and males, represented by 53.4% (n=55) males and 46.6% (n=48) females. Their age group was 4-5 years, 47.6% (n=49) four years of age and 52.4% (n=54) were 5 years as illustrated in Table 4.5. They had a mean of 17.86Kgs, 103.83cm, 15.4cm, weight, height and MUAC respectively. The maximum weight recorded was 30kgs while the minimum weight was 11Kgs. The standard deviation for the Z-score was 0.728 with a negative skewness of – 0.526

Table 4.5 *Demographic Data*

DEMOGRAPHIC DATA					
Children (n=103)			**Adults (n=48)**		
Gender					
	Frequency	**Percentage (%)**		**Frequency**	**Percentage (%)**
Male	55	53.4	Male	12	25
Female	48	46.6	Female	36	75
Total	103	100	**Total**	48	100
			Mean Weight		71.3Kgs
Age (Years)					
4 years	49	47.6	**25 -34**	6	12.5
5 years	54	52.4	**35-44**	26	54.2
Total	103	100	**45-54**	16	33.3
			Total		100
Mean Weight		17.9Kgs	**Mean Weight**		71.3Kgs
Mean Height		103.8cm			
Mean MUAC		15.4cm			

4.4.2 Sensory evaluation and acceptability of tamarillo honey jam

Familiarity and appearance of tamarillo honey jam

The respondents were given samples of tamarillo honey jam for observation and tasting. Focus group discussions proceeded and recordings were done. The study revealed that more than half of the respondents 85% (n=41) liked the appearance of the tamarillo honey jam. They relied on their memory of previous products that they had bought or seen in the shelves and used some of them like tomato paste, peanut butter, food colour and honey based on the packaging to describe tamarillo Honey Jam. It was also noted that some of the respondents had not previously interacted with tamarillo fruit at individual levels. The few that had interacted with it also revealed that they did not necessarily like the natural

taste of the fruit. Some revealed that it was grown in their homes some time back when they were still kids. Below are some descriptions by the respondents attributed to tamarillo:

"*I think sometimes inside the fruit you find it is red, yellow*."

"*Yes, I know it, looks like a tomato. And people think it adds blood."*

Responses from respondents, Kakamega (4/6/2022)

The above statements revealed that the respondents who had prior interacted with the fruit not only knew the fruit but could also describe it well. It also revealed they knew the family in which it belongs; the tomato family.

The study also found out that most who had eaten the tamarillo fruit preferred sucking it directly in the mouth without cutting it with a knife. It was also eaten leisurely during walks or in the middle of activities without necessarily including it as part of meal times.

Taste and texture

They all had the opportunity to eat the jam through licking and applying it on bread. The results revealed that majority of them appreciated the taste though a larger percentage of those who were ages of 35 and below highly recommended addition of honey to make it a bit sweeter. The other generation of 35 years and above liked the jam and suggested the taste be maintained as it is. A respondent who was keen to cater for all age groups said:

"*I want to tell you where by you can have two types"*

"*How I wish you could have put in a lot of honey."*

"Am talking on behalf of the old people, we don't need a lot of sugar."

"At least you can specify for those people who cannot take that which is so sweet at all times. That's when you will be catering for all the needs."

Responses from respondents, Kakamega (17/6/2022)

The respondent indicated that their taste depended a lot on their age. The younger ones insisted on more sugary things unlike the older ones.

Smell

The study revealed that the jam had a sweet attractive smell. All the participants agreed to it and ended up comparing it to familiar smells that they interacted with, i.e., Passion fruit, tamarind, orange, honey.

"*Oh, this smell exactly like passion fruits.*"

"I think it smells like tamarind and passion fruits."

Responses from respondents, Kakamega (16/6/2022)

The study revealed that smell was a great influence of sensory attributes and most of them indicated that they were attracted to tamarillo honey jam due to its characteristic smell. Several had varying opinions. As others indicated it smelt like passion fruit, others agreed on orange like smell and honey like smell. This showed that they were able to identify the major ingredients making up the tamarillo honey jam which are tamarillo fruit and honey.

Tamarillo jam improvement

The respondents were able to give the feedback on areas of improvement and their recommendations. They suggested the color should have been redder to what they are used to. Some indicated should have lots of tamarillo honey jam manufactured since it is easily spreadable. The participants suggested they could easily recommend it to their family members since they want to all eat healthy. Others would recommend it to their friends who are keen on what they eat. One also requested that the product should have a label that clearly outlines all the contents present. A responded said she would recommend it to her aging relatives.

> *"You can add the list of ingredients on the label for more awareness."*
>
> *"I usually buy it, it is somehow red, dark and I also have them in the house. I would easily buy the jam"*
>
> *"Let the product remain as it is."*
>
> Responses from respondents, Kakamega (16/6/2022)

Word Cloud Query Results.

A word cloud query was also run to reveal the most commonly 100 appearing words in the discussions responses of the focus group interviews. This revealed that honey, fruit, taste, among others were highly mentioned during the discussions. Honey being the most mentioned revealed that the respondents were familiar with it and attributed to its nutritional benefits.

Figure 4.0.1 *Word query search for Focus Group Interviews*

Preschoolers' Questionnaire Responses.

This data represents the summary of all 7 randomly selected schools within Lurambi Sub County in Kakamega County.

Use of jam

Preschoolers were also evaluated on use of jam before and 19.4% (n=20) of the sampled participants had not consumed any jam before while 80.6% (n=83) had interacted and eaten different types of jam before. Out of the 83, 31.3% (n=26) bought their jam from the shop while 67.8% (n=57) bought it from the supermarket as demonstrated in Figure 4.2.

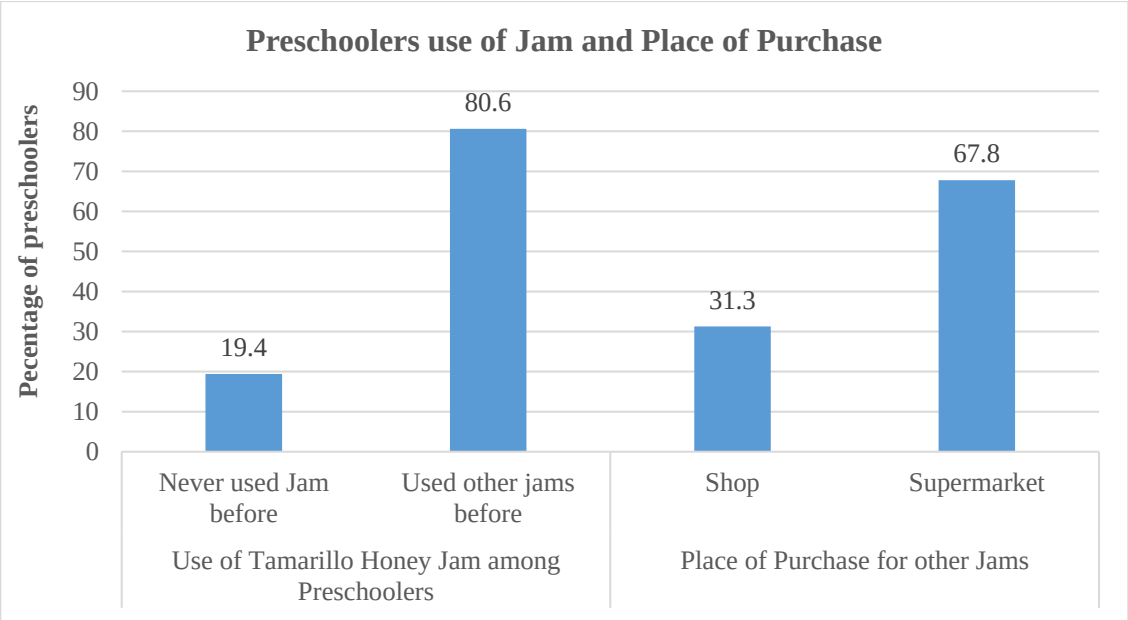


Figure 4.0.2 *Combined distribution on use of jam for preschoolers and place of purchase*

Acceptability of tamarillo jam among preschoolers

96.1% (n=99) liked the appearance of the jam very much while 2.9% (n=3) liked it moderately and 1% (n=1) disliked extremely. The participants had a chance of each opening their samples and smell it and 2.9% liked the smell extremely, 88.3% (n=91) liked it very much, 6.8% (n=7) liked it moderately and 1.9% (n=2) disliked it extremely. On tasting the product, 1% liked it extremely since they could smell it over and over again. 82.5% (n=85) liked the taste of tamarillo honey jam very much, 12.6% (n=13) liked it moderately, 1.9% (n=2) disliked it very much while the remaining 1.9% (n=2) disliked it extremely to the extent they could not eat the jam. Concerning the mouthfeel, fluidity and acceptability of the jam, 83.5% (n=86) liked it very much, 12.6% (n=13) liked it

moderately, 1.9% (n=2) disliked very much and the remaining 1.9% (n=2) disliked it extremely.

Table 4.6 *General Acceptability Test*

General Acceptability test

Hedonics	**Parameters**											
	Appearance		**Smell**		**Taste**		**Mouthfeel**		**Fluidity**		**Acceptability**	
Like extremely			3	2.9%	1	1%						
Like very much	99	96.1%	91	88.3%	85	82.5%	86	83.5%	86	83.5%	86	83.5%
Like moderately	3	2.9%	7	6.8%	13	12.6%	13	12.6%	13	12.6%	13	12.6%
Dislike very much					2	1.9%	2	1.9%	2	1.9%	2	1.9%
Dislike extremely	1	1%	2	1.9%	2	1.9%	2	1.9%	2	1.9%	2	1.9%
Total No.	103		103		103		103		103		103	
Percentage		100		100		100		100		100		100

Summary of the results

The above results revealed that most of the participants available for the study were female unlike males both for the preschoolers and the adults. Adults(Parents and teachers) (25-60) years male was 25% (n=12) and female were 75% (n=36) with a mean weight of

71.25Kgs. Preschoolers 53.4% (n=55) male and 46.6% (n=48) female with a mean weight of 17.86Kgs, height of 103.83cm, MUAC of 15.4cm and a negative skewed Z- score of –0.526.

On the sensory evaluation and acceptability of tamarillo honey jam among preschoolers based on appearance, taste, smell, mouthfeel, fluidity and acceptability is summarized in Table 4.4.

Adults' sensory evaluation and acceptability of tamarillo honey jam revealed; respondents who had prior interacted with the fruit knew it and the family in which it belonged that is the tomato family. Most respondents who had eaten the tamarillo fruit preferred sucking it directly in the mouth without cutting it with a knife. It was also eaten leisurely during walks or in the middle of activities without necessarily including it as part of meal times. The respondent indicated that their taste depended a lot on their age. The younger ones insisted on more sugary things unlike the older ones. The study revealed that smell was a great influence of sensory attributes and most of them indicated that they were attracted to tamarillo honey jam due to its characteristic smell. Finally they suggested the color should have been redder to what they are used to. Some indicated should have lots of tamarillo honey jam manufactured since it is easily spreadable. The participants suggested they could easily recommend it to their family members since they want to all eat healthy. Others would recommend it to their friends who are keen on what they eat.

CHAPTER 5

DISCUSSION

5.0 Introduction

This chapter discusses the results of the study and incorporates views from other researchers. The discussion covers the method for preparation of tamarillo honey jam, and the proximate and micronutrient composition. The microbiological limit of yeasts and moulds, salmonella, coliform and Escherichia coli, safety and quality standards of developed tamarillo honey jam and the influence of sensory attributes and acceptability of tamarillo honey jam on preschool children (4-5) years and adults(Parents and teachers) (25-60) years (25-60) years.

5.1 Method of preparation for tamarillo honey jam

In jam production, the raw materials, refined table sugar and fruits are mixed in same proportion that is 50% of fruit pulp and 50% of sugar. The mixture is then cooked to produce delicious product with a longer shelf life. Several fruits have been used to add value to food products like jams (Mohd Naeem et al., 2017). Tamarillo honey jam on the other hand sought to use the tamarillo fruits and honey instead of table sugar as raw materials which were mixed in different proportions. The final product consisted of 64.93% (4.3 kg) of fruit pulp, 32.45% (2.15 kg) of honey, 2.59% (0.172 kg) of pectin and 0.03% (0.002 kg) preservatives. The amount of honey used was half the amount unlike table sugar in normal jams demonstrating the sweetness of honey according to (Keskin *et al.*, 2021). The percentage of fructose (35–40%) and glucose (30–35%) with fructose being a naturally occurring sweetener that is the sweetest instead of table sugar in the

formulation of tamarillo honey jam (Bobiş et.al, 2018). Tamarillo fruit is naturally high in pectin but concentrated on the peels, which are not utilized during the production process. Commercial Pectin was used instead to help in gelling the jam according to Casadei & Albert (2015) for this particular product pectin used was at 3% of the fruit pulp that led to the desired firm but soft consistency of the jam that is easily spreadable. Potassium sorbet and/or sodium benzoate are added at 0.05% which is a tolerable limit (Nations, 1992) to prevent spoilage and inhibiting growth of moulds and yeasts according to Khan et al., (2014). This therefore justifies the need for use of preservatives. The final Brix of 73°Bx revealed that honey incorporation in jams, increases the amount of total soluble solids in the final product due to its high concentration of glucose and fructose. As Ullah et al., (2018) indicates that jams could also mean an intermediate moisture food prepared by cooking sugar with fruit pulp, acid and other ingredients to achieve a sensible consistency, in this case acid was eliminated during the production process. The citric acid which according to (Nations, 1992) is added to improve the PH of the fruit was withdrawn since the first trial and the second revealed high acidity levels of a PH of 1.3 proving tamarillo in itself is rich in citric acid.

5.2 Analysis of proximate and micronutrient composition of developed tamarillo honey jam

Proximate composition

The tamarillo honey jam had a moisture content of 21.5% which statistically has no significance yet in processed jams, a low moisture content reveals that the jam has a longer shelf life (Mohd Naeem *et al.*, 2017). The protein content of the jam was 0.1% of the

tamarillo honey jam, which is significant since the key ingredients used in the production are fruits, honey and pectin, which are known to have insignificant amounts of proteins. This was compared to strawberry, blueberry jams developed in Malaysia which had significantly lower levels of (0.1-0.4)% (Mohd Naeem *et al*., 2017). The carbohydrate content reported was 77.82%. Majorly jams carbohydrates content are attributed to the sugars added in this case honey was added which is a rich source of monosaccharides that is glucose and fructose (Keskin *et al*., 2021).

The fat content was 0.36% of the jam sample this is attributed to low fat content of fruits varying on the different types of fruits used (Keskin *et al*., 2021). This data compares to that of other previously processed jams like watermelon, pineapple and banana which were ranging (0.25-3.85%) (Rana *et al*., 2021) The crude fibre content of tamarillo honey jam was 0.02% as per (ISO 6541). The various ranges of processed jams crude fibre reported previously by (Rana *et al*., 2021) were 0.09-0.54%. The ash content usually indicates the jam is a rich source of minerals according to (Mohd Naeem *et al.*, 2017).the tamarillo honey jam had total ash content of 0.22% compared to previous reported range of 0.30-0.37% (Rana *et al.*, 2021).

Mineral and Vitamin and composition

Mineral composition of tamarillo honey jam of Zinc 0.03 mg/100g, Iron 0.08 mg/100g, Potassium 0.01 mg/100g, Sodium 1.09mg/100g and Magnesium 2.3 mg/100g represent 0.2% zinc, 0.1% Iron, 0.002% potassium and 0.6% magnesium of recommended Daily allowances for individuals. Tamarillo honey jam will be able to provide a range of minerals and vitamins to help address the micronutrient needs. Tamarillo honey jam had

Vitamin C content of 49.63µg/100g compared to the raw fruit content of 29.8 mg/100g. The low levels of vitamin c are associated to denaturation during the cooking process of the jam since most of it is always lost (Mertz *et al*., 2010). Vitamin A 0.3 µg/100g and Vitamin E 0.2 µg/100g representing 0.03% and 0.01 of Daily Recommended Dietary Intake.

5.3 The microbiological limit of yeasts and moulds, salmonella, coliform and Escherichia coli, safety and quality standards of developed tamarillo honey jam

The yeasts and moulds content of the tamarillo honey jam were <10 colony forming units indicating the safety of the product. This has also been linked to high acidity levels of the jam with a ph. of 3.0 inhibiting growth of yeasts and moulds as cited by(Rana *et al*., 2021). Tamarillo fruit cointains ascorbic acid, contributed to high acidity levels (Acosta-Quezada *et al*., 2016) amounting to total acidity of 1.0-2.4 mg/100 g Bakshi *et al. (2016).* Honey equally contributed to acidity levels due to its acidic ph with the presence of phenolic acids (Bobiş et.al, 2018).

The colony forming units of Coliform also met the standards since they were <10 indicating safety of the product.

5.4 Influence of sensory attributes and acceptability of tamarillo honey jam on preschool children (4-5) years and adults (Parents and teachers) (25-60) years (25-60) years.

Usually sensory science incorporates use of the five senses; touch, smell, sound, sight and taste to measure and evaluate individuals appeal to products (Rana et al., 2021). This study

incorporated use of the human senses that is; smelling, tasting, appearance and tasting tamarillo honey jam. It revealed more than half of the respondents 85% (n=41) liked the appearance of the tamarillo honey jam being highly acceptable among majority of respondents except those who could not tolerate it based on the prior experience with its taste. It has a distinctive acidic flavor, an attractive deep skin and flesh as attributed by (Schotsmans et al., 2011). The study found out that 75% (n=36) of the respondents appreciated the taste, identified the characteristic flavour and could point it out especially among the adults. The acceptable taste levels among preschoolers were higher at 83% liking it very much and extremely which indicated that the jam was acceptable. The appearance and smell were highly acceptable among both the adults and children. The high sensory values of 96.1% (n=99) liking the appearance of the jam very much while 2.9% (n=3) liking it moderately and 1% (n=1) disliking extremely. 2.9% liking the smell extremely, 88.3% (n=91) liking it very much, 6.8% (n=7) liking it moderately and 1.9% (n=2) disliking it extremely. The above results were qualified by the nine-point hedonic scale and could be linked to the characteristic flavour of tamarillo, its colour and honey incorporated in it. This shows that a tamarillo honey jam could be consumed among majority of the adults and preschoolers and the preference levels were high. This is compared to high acceptability levels of fruit jams like pineapple, watermelon and banana with high sensory values due to texture, colour and flavour (Emelike et.al, 2019). A few adults (Parents and teachers) (25-60) years and preschoolers (4-5) years who could not tolerate the jam showed that the product was not 100% acceptable.

CHAPTER 6

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.0 Introduction

This chapter summarizes the key conclusions as per the study findings and provide key recommendations that would inform other areas of study with emphasis on practice, policy making and future research.

6.1 Conclusions on the key findings

The purpose of this study was to develop tamarillo honey jam, determine its proximate and micronutrient composition, establish its microbiological limit of yeasts and moulds, salmonella and Escherichia coli, safety and quality standards and determine its sensory acceptability on preschoolers (4-5) years and (Parents and teachers) (25-60) years. The conclusions are herein outlined as per the research objectives.

6.1.1 Method of preparation for tamarillo honey jam

Development of tamarillo jam revealed that it is possible to incorporate honey in our jams and come up with acceptable and nutritious products for human consumption. The study showed that for one to develop this type of jam, the selection of proper raw materials start from the farm and a rigorous process has to be followed before achieving a product. This also indicated that the tamarillo fruits could be preserved for longer periods of time when converted into jams to minimize on its spoilage and wastage due to its high levels of perishing.

6.1.2 Analysis of proximate and micronutrient composition of developed tamarillo honey jam

This study has revealed that tamarillo honey jam is a rich source of energy from the honey incorporated with distribution of other micronutrients such as Vitamin A, C, Trace elements; and less in fat. It therefore could act as reference point for value added foods and help nutrition professional increase diversity in helping individuals make healthier and nutritious food choices.

6.1.3 The microbiological limit of yeasts and moulds, salmonella, coliform and Escherichia coli, safety and quality standards of developed tamarillo honey jam

Tamarillo honey jam was developed under highly hygienic environment and food safety standards were upheld. Sterilized and food grade containers were also used for packaging. Tamarillo honey jam was tested and found safe for human consumption. This showed that subjecting tamarillo honey jam to microbial and safety analysis, revealed that it is possible to maintain safety of our product during production and therefore improve knowledge of consumers through food safety awareness.

6.1.4 Influence of sensory attributes and acceptability of tamarillo honey jam on preschool children (4-5) years and adults (Parents and teachers) (25-60) years.

The overall acceptability of tamarillo honey jam was generally high among the preschoolers who liked the appearance, taste and smell. Among the It revealed more than half of the respondents 85% (n=41) liked tamarillo honey jam and revealed that tamarillo

fruit was not new to them. This revealed that the acceptability of honey-based jams is higher and could possibly match the needs of individuals and market.

6.2 Recommendations

The recommendations outlined below were made.

6.2.1 Recommendations for Practice

1. Explore the use of honey in developing other fruit jams to increase consumption of variety of healthy fruit choice jams.
2. During jam processing it is important to evaluate the fruit acidity levels to utilize the natural ph. of fruits fruits instead of additional commercial acids.
3. Safety standards should be upheld in the food production facilities to ensure safe products for consumers.

6.2 Recommendations for Future research

1. More research should be done to evaluate the storage and stability of tamarillo honey jam compared to those present in the market.
2. A comparative study for other types of jam with tamarillo honey jam should be done to determine their health impact.
3. A longitudinal study should be done to establish the long-term effect of tamarillo honey jam on health and nutrition of children as well as adults.

REFERENCES

[AOAC]. Association of Official Analytical Chemistry International. (2005). Official Methods of Analysis of AOAC INTERNATIONAL. Aoac, February.

Abdul Mutalib, M., Rahmat, A., Ali, F., Othman, F., & Ramasamy, R. (2017). Nutritional compositions and antiproliferative activities of different solvent fractions from ethanol extract of cyphomandra betacea (Tamarillo) fruit. Malaysian Journal of Medical Sciences, 24(5). https://doi.org/10.21315/mjms2017.24.5.3

Abu-Jdayil, B., Al-Majeed Ghzawi, A., Al-Malah, K. I. M., & Zaitoun, S. (2002). Heat effect on rheology of light- and dark-colored honey. Journal of Food Engineering, 51(1). https://doi.org/10.1016/S0260-8774(01)00034-6

Acosta-Quezada, P. G., Riofrío-Cuenca, T., Rojas, J., Vilanova, S., Plazas, M., & Prohens, J. (2016). Phenological growth stages of tree tomato (Solanum betaceum Cav.), an emerging fruit crop, according to the basic and extended BBCH scales. Scientia Horticulturae, 199, 216–223. https://doi.org/https://doi.org/10.1016/j.scienta.2015.12.045

Almasaudi, S. B., Al-Nahari, A. A. M., Abd El-Ghany, E. S. M., Barbour, E., Al Muhayawi, S. M., Al-Jaouni, S., Azhar, E., Qari, M., Qari, Y. A., & Harakeh, S. (2017). Antimicrobial effect of different types of honey on Staphylococcus aureus. Saudi *Journal of Biological Sciences*, 24(6). https://doi.org/10.1016/j.sjbs.2016.08.007

Anon. (2015). 'Tree Tomato Production - Greenlife Crop Protection Africa'. https://www.greenlife.co.ke/tree-tomato-production>.

Anon. (2020). Sustainable development goals https://www.un.org/sustainabledevelopment/sustainable-development-goals/

AOAC. (2005). Official Methods of Analysis of AOAC International, 18th ed. AOAC International, Maryland, USA.

AOAC. (2006). Official Methods of Analysis of AOAC International, 18th ed. 1st Revision. AOAC International, Maryland, USA.

AOAC. (2008). Official Methods of Analysis of AOAC International, 18th ed. 2nd Revision. AOAC International, Maryland, USA

Baglio, E. (2018). Overheating Indexes and Honey Quality.

https://doi.org/10.1007/978-3-319-65751-6_3

Bakshi, P., Kour, G. and Ahmed, R. (2016). Tamarillo (Cyphomandra betacea). In: "Underutilized Fruit Crops: Importance and Cultivation" (1st ed.). (S. N. Ghosh, Ed.). pp. 1271-1294. India. Jaya Publications.

Banning, Maggi. (2005). 'Conceptions of Evidence, Evidence-Based Medicine, Evidence-Based Practice and Their Use in Nursing: Independent Nurse Prescribers' Views.' *Journal of Clinical Nursing* 14(4):411–17. https://doi:10.1111/j.1365-2702.2004.01086.x.

Bobiş, O., Dezmirean, D. S., & Moise, A. R. (2018). Honey and Diabetes: The Importance of Natural Simple Sugars in Diet for Preventing and Treating Different Type of Diabetes. In *Oxidative Medicine and Cellular Longevity* (Vol. 2018). Hindawi Limited. https://doi.org/10.1155/2018/4757893

Bodor, Z., Koncz, F., Zinia Zaukuu, J.-L., Kertész, I., Gillay, Z., Kaszab, T., Kovács, Z., & Benedek, C. (2017). Effect of Heat Treatment on Chemical and Sensory Properties of Honeys. Animal Welfare, Etológia És Tartástechnológia, 13(2). https://doi.org/10.17205/SZIE.AWETH.2017.2.039

Bogdanov, S., Jurendic, T., Sieber, R., & Gallmann, P. (2008). Honey for nutrition and health: A review. Journal of the American College of Nutrition, 27(6), 677–689. https://doi.org/10.1080/07315724.2008.10719745

Boyes, S., & Strübi, P. (1997). Organic acid and sugar composition of three New Zealand grown tamarillo varieties (Solarium betaceum (Cav.)). New Zealand Journal of Crop and Horticultural Science, 25(1). https://doi.org/10.1080/01140671.1997.9513990

Braghini, F., Biluca, F. C., Gonzaga, L. V., Kracik, A. S., Vieira, C. R. W., Vitali, L., Micke, G. A., Costa, A. C. O., & Fett, R. (2019). Impact of short-term thermal treatment on stingless bee honey (Meliponinae): Quality, phenolic compounds and antioxidant capacity. *Journal of Food Processing and Preservation*, 43(7). https://doi.org/10.1111/jfpp.13954

Cardello, A. V, and S. R. Jaeger. (2010). '7 - Hedonic Measurement for Product Development: New Methods for Direct and Indirect Scaling'. Pp. 135–74 in *Consumer-Driven Innovation in Food and Personal Care Products, Woodhead Publishing Series in Food Science, Technology and Nutrition*, edited by Sara R Jaeger and H. MacFie. Woodhead Publishing.

Casadei, E., and J. Albert. (2015). FAO 'Food and Agriculture Organization of the United Nations'. *Encyclopedia of Food and Health* 749–53. https://doi:10.1016/B978-0-12-384947-2.00270-1.

Christofi, M., Vrontis, D., & Leonidou, E. (2014). Product innovation and cause-related marketing success: A conceptual framework and a research agenda. Marketing Intelligence and Planning, 32(2). https://doi.org/10.1108/MIP-10-2012-0108

Cianciosi, D., Forbes-Hernández, T. Y., Afrin, S., Gasparrini, M., Reboredo-Rodriguez, P., Manna, P. P., Zhang, J., Lamas, L. B., Flórez, S. M., Toyos, P. A., Quiles, J. L., Giampieri, F., & Battino, M. (2018). Phenolic compounds in honey and their associated health benefits: A review. In Molecules (Vol. 23, Issue 9). https://doi.org/10.3390/molecules23092322

De Rosso, V. V., & Mercadante, A. Z. (2007). HPLC-PDA-MS/MS of anthocyanins and carotenoids from dovyalis and tamarillo fruits. *Journal of Agricultural and Food Chemistry*, 55(22). https://doi.org/10.1021/jf071316u

Diep, T. T., Pook, C., & Yoo, M. J. Y. (2020). Physicochemical properties and proximate composition of tamarillo (Solanum betaceum Cav.) fruits from New Zealand. *Journal of Food Composition and Analysis*, 92. https://doi.org/10.1016/j.jfca.2020.103563

Do Nascimento, G. E., Iacomini, M., & Cordeiro, L. M. C. (2016). A comparative study of mucilage and pulp polysaccharides from tamarillo fruit (Solanum betaceum Cav.). Plant Physiology and Biochemistry, 104. https://doi.org/10.1016/j.plaphy.2016.04.055

Donadini, G., Porretta, S., Fumi, M. D., & Spigno, G. (2022). Preschoolers' liking of citrus fruits served as a mid-morning snack. Food Control, 142, 109159. https://doi.org/https://doi.org/10.1016/j.foodcont.2022.109159

Ekinci, Raci & Kadakal, çetin. (2005). Determination of seven water-soluble vitamins in tarhana, a traditional Turkish cereal food, by high-performance liquid chromatography, Acta Chromatographica. 15.

El Sohaimy, S. A., Masry, S. H. D., & Shehata, M. G. (2015). Physicochemical characteristics of honey from different origins. Annals of Agricultural Sciences, 60(2). https://doi.org/10.1016/j.aoas.2015.10.015

Emelike, Njt, and Akusu OM. 2019. 'Quality Attributes of Jams and Marmalades Produced from Some Selected Tropical Fruits'. *Journal of Food Process Technology* 10(5):1–7. https://doi:10.4172/2157-7110.1000790

FAO, IFAD, UNICEF, WFP and WHO. (2021). The State of Food Security and Nutrition in the World 2021. Transforming food systems for food security, improved nutrition and affordable healthy diets for all. Rome, FAO. https://doi.org/10.4060/cb4474en

FAO/WHO. (2014). 'The Nutrition Challenge'.

Ferreira Da Cruz, B. C., Ronqui, L., Scharnoski, P., Scharnoski, P., Peruzzolo, M., Da, P., Santos, R., Halak, A., Wielewski, P., Magro, J. M., & Fernanda De Araujo, K. (2019). Health Benefits of Honey. www.intechopen.com

Gannasin, S. P., Adzahan, N. M., Hamzah, M. Y., Mustafa, S., & Muhammad, K. (2015). Physicochemical properties of tamarillo (Solanum betaceum Cav.) hydrocolloid fractions. Food Chemistry, 182. https://doi.org/10.1016/j.foodchem.2015.03.010

Gannasin, S. P., Ramakrishnan, Y., Adzahan, N. M., & Muhammad, K. (2012). Functional and preliminary characterisation of hydrocolloid from tamarillo (Solanum betaceum Cav.) puree. Molecules, 17(6). https://doi.org/10.3390/molecules17066886

Guimarães, M. L., M. C. Tomé, and G. S. Cruz. (1996). 'Cyphomandra Betacea (Cav.) Sendtn. (Tamarillo)'. Pp. 120–37 in *Trees IV*, edited by Y. P. S. Bajaj. Berlin, Heidelberg: Springer Berlin Heidelberg.

Hager, C. (2006). Determining degree of innovation in business models by applying product innovation theory. University of Oslo.

Hannah Ritchie and Max Roser (2017) - "Micronutrient Deficiency". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/micronutrient-deficiency'[Online Resource]

Jahan, N., Islam, M. A., Alam, F., Gan, S. H., & Khalil, M. I. (2015). Prolonged heating of honey increases its antioxidant potential but decreases its antimicrobial activity. *African Journal of Traditional, Complementary and Alternative Medicines*, 12(4). https://doi.org/10.4314/ajtcam.v12i4.20

Jajda, H. M., Patel, K. G., Patel, S. R., Solanki, V. H., Patel, K. N., & Singh, S. (2015). Comparative efficacy of two standard methods for determination of iron and zinc in

fruits, pulses and cereals. *Journal of Food Science and Technology*, 52(2). https://link.springer.com/article/10.1007/s13197-013-1088-6

Joshi, B. (2018). Preparation and Storage Stability Evaluation of Tamarillo Sauce With Varying Storage Temperature and Packaging Material. 1–74.

Kaiser, U. (2005). Product Innovation and Product Innovation Marketing: Theory and Microeconometric Evidence. SSRN Electronic Journal. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=358321

Kenya Ministry of Health. (2018). 'Kenya Nutrition Action Plan (KNAP)'.

Keskin, Merve, Şaban Keskin, and Sevgi Kolaylı. (2021). 'Chapter 17 - Health-Promoting Benefits of Honey'. Pp. 303–6 in *Preparation of Phytopharmaceuticals for the Management of Disorders*, edited by C. Egbuna, A. P. Mishra, and M. R. Goyal. Academic Press.

Khan, S., Anwar, K., Kalim, K., Saeed, A., & Shah, S. Z. (2014). Nutritional Evaluation of Some Top Fodder Tree Leaves and Shrubs of District Dir (Lower), Pakistan as a quality livestock feed. Int. J. Curr. Microbiol. App. Sci, 3(5), 941–947. http://www.ijcmas.com/vol-3-5/Sartaj

Khan, Uzair, Javid Ullah, Beena Saeed, and Farman Ali. 2014. 'Effect of Potassium Sorbate and Sodium Benzoate on The Quality And Shelf-Life Of Strawberry Jam During Storage'. 9(12):454–58.

Klagge, J. (2018). For focus group discussions, *Guidelines for Conducting Focus Groups*. https://doi.org/10.13140/RG.2.2.33817.47201

Lau, K. Q., Sabran, M. R., & Shafie, S. R. (2021). Utilization of Vegetable and Fruit By-products as Functional Ingredient and Food. *Frontiers in Nutrition*, *8*. https://doi.org/10.3389/fnut.2021.661693

Lin, H., & Lin, E. S. (2010). FDI, Trade, and Product Innovation: Theory and Evidence. Southern Economic Journal, 77(2). https://doi.org/10.4284/sej.2010.77.2.434

Lister, Carolyn, Sarah Morrison, N. Kerkhofs, and Kathryn Wright. (2005). 'The Nutritional Composition and Health Benefits of New Zealand Tamarillos'. *Crop & Food Research Confidential Report No. 1281*.

Lundvall, B. Å., & Vinding, A. L. (2004). Product innovation and economic theory - user-producer interaction in the learning economy. In Research on Technological

Innovation, Management and Policy (Vol. 8). https://doi.org/10.1016/S0737-1071(04)08005-9

Manual, Practical, and Food Chemistry. n.d. 'Experiment 4 Determination of Reducing Sugars, Total Reducing Sugars , Sucrose And'.

Maqsood, Maria, Barbara Dancheck, Mary V. Gamble, Neal A. Palafox, Michelle O. Ricks, Kennar Briand, and Richard D. Semba. (2004). 'Vitamin A Deficiency and Inflammatory Markers among Preschool Children in the Republic of the Marshall Islands'. *Nutrition Journal* 3:1–6. https://doi:10.1186/1475-2891-3-21

Mayo-Wilson, Evan, Aamer Imdad, Kurt Herzer, Mohammad Yawar Yakoob, and Zulfiqar A. Bhutta. (2011). 'Vitamin A Supplements for Preventing Mortality, Illness, and Blindness in Children Aged under 5: Systematic Review and Meta-Analysis.' *BMJ (Clinical Research Ed.)* 343:d5094. https://doi:10.1136/bmj.d5094

Meo, S. A., Al-Asiri, S. A., Mahesar, A. L., & Ansari, M. J. (2017). Role of honey in modern medicine. In Saudi Journal of Biological Sciences (Vol. 24, Issue 5). https://doi.org/10.1016/j.sjbs.2016.12.010

Mertz, C., Brat, P., Caris-Veyrat, C., & Gunata, Z. (2010). Characterization and thermal liability of carotenoids and vitamin C of tamarillo fruit (Solanum betaceum Cav.). Food Chemistry, 119(2). https://doi.org/10.1016/j.foodchem.2009.07.009

Miller, D. D., & Welch, R. M. (2013). Food system strategies for preventing micronutrient malnutrition. (Special Section: Food systems and the triple burden of malnutrition.). *Food Policy*, *42*(13), 115–128.

Mohd Naeem, M. N., Mohd Fairulnizal, M. N., Norhayati, M. K., Zaiton, A., Norliza, A. H., Wan Syuriahti, W. Z., Mohd Azerulazree, J., Aswir, A. R., & Rusidah, S. (2017). The nutritional composition of fruit jams in the Malaysian market. *Journal of the Saudi Society of Agricultural Sciences*, *16*(1), 89–96. https://doi.org/10.1016/j.jssas.2015.03.002

Muliarta, M., Tirtayasa, K., Prabawa, P. Y., & Wiryadana, K. A. (2020). Tamarillo consumption associated with increased acetylcholinesterase activity and improved oxidative stress markers in farmers exposed to daily pesticide-related activities in baturiti, Bali, Indonesia. Open Access Macedonian Journal of Medical Sciences, 8(E). https://doi.org/10.3889/oamjms.2020.3265

Murray, J. M., and I. A. Baxter. 2003. 'SENSORY EVALUATION | Food Acceptability and Sensory Evaluation'. Pp. 5130–36 in *Encyclopedia of Food Sciences and Nutrition (Second Edition)*, edited by B. Caballero. Oxford: Academic Press.

Mwangi, P. (2016). Spreads Industry Market Analysis. December.

Nallakurumban, P., Sujar, N., Vijayakumar, A., Geetha, P. S., & Karpagapandi, L. (2015). Estimation of Phytochemicals and Antioxidant Property of Tamarillo (Solanum betaceum) and A Value Added Product Tamarillo Sauce. International Journal of Scientific Progress and Research (IJSPR), 9(2).

Nassaji, Hossein. 2015. 'Qualitative and Descriptive Research: Data Type versus Data Analysis'. *Language Teaching Research* 19(2):129–32. https://doi:10.1177/1362168815572747

Nations, U. (1992). No preservatives. Nature, 355(6363), 774. https://doi.org/10.1038/355774a0

Nicklaus, S., & Tournier, C. (2023). 11 - Relationships between early flavor/texture exposure, and food acceptability and neophobia. In E. Guichard & C. Salles (Eds.), Flavor (Second Edition) (Second Edition, pp. 301–327). Woodhead Publishing. https://doi.org/https://doi.org/10.1016/B978-0-323-89903-1.00002-5

Osorio, C., Hurtado, N., Dawid, C., Hofmann, T., Heredia-Mira, F. J., & Morales, A. L. (2012). Chemical characterisation of anthocyanins in tamarillo (Solanum betaceum Cav.) and Andes berry (Rubus glaucus Benth.) fruits. Food Chemistry, 132(4). https://doi.org/10.1016/j.foodchem.2011.12.026

Popper, R., and J. J. Kroll. 2011. '9 - Consumer Testing of Food Products Using Children'. Pp. 163–87 in *Developing Children's Food Products*, *Woodhead Publishing Series in Food Science, Technology and Nutrition*, edited by D. Kilcast and F. Angus. Woodhead Publishing.

Rana, M. S., Yeasmin, F., Khan, M. J., & Riad, M. H. (2021). Evaluation of quality characteristics and storage stability of mixed fruit jam. *Food Research*, *5*(1), 225–231. https://doi.org/10.26656/fr.2017.5(1).365

Rickman JC, Barrett DM, Bruhn CM (2007b) Nutritional comparison of fresh, frozen and canned fruits and vegetables. Part 1. Vitamins C and B and phenolic compounds. J Sci Food Agric 87(6):930–944.

Sharma, S., Vaidya, D., & Rana, N. (2016). Honey as Natural Sweetener in Lemon Ready-

to-Serve Drink. *International Journal of Bio-Resource and Stress Management*, *7*(2), 320–325. https://doi.org/10.23910/IJBSM/2016.7.2.1389

Schotsmans, W. C., A. East, and A. Woolf. (2011). '21 - Tamarillo (Solanum Betaceum (Cav.))'. Pp. 427-442e in *Postharvest Biology and Technology of Tropical and Subtropical Fruits, Woodhead Publishing Series in Food Science, Technology and Nutrition*, edited by E. M. Yahia. Woodhead Publishing.

Sree, L. T., & Vijayalakshmi, K. (2018). Proximate Composition, Nutritional Evaluation and Mineral Analysis in the Leaves of an Indigenous Medicinal Plant, Alternanthera Sessilis. International Journal of Health Sciences & Research (Www.Ijhsr.Org), 8(7), 55.

Stevens, G. A., Beal, T., Mbuya, M. N. N., Luo, H., Neufeld, L. M., Addo, O. Y., Adu-Afarwuah, S., Alayón, S., Bhutta, Z., Brown, K. H., Jefferds, M. E., Engle-Stone, R., Fawzi, W., Hess, S. Y., Johnston, R., Katz, J., Krasevec, J., McDonald, C. M., Mei, Z., … Young, M. F. (2022). Micronutrient deficiencies among preschool-aged children and women of reproductive age worldwide: a pooled analysis of individual-level data from population-representative surveys. *The Lancet Global Health*, *10*(11), e1590–e1599. https://doi.org/10.1016/S2214-109X(22)00367-9

Stone, Herbert, Rebecca N. Bleibaum, and Heather A. Thomas. 2021. 'Chapter 7 - Affective Testing'. Pp. 297–336 in *Sensory Evaluation Practices (Fifth Edition)*, edited by H. Stone, R. N. Bleibaum, and H. A. Thomas. Academic Press.

Takaichi, Shinichi. 2000. 'Characterization of Carotenes in a Combination of a C18 HPLC Column with Isocratic Elution and Absorption Spectra with a Photodiode-Array Detector'. *Photosynthesis Research* 65(1):93–99. doi: 10.1023/A:1006445503030.

Tree Tomato Production | Greenlife | Update 2023. https://www.greenlife.co.ke/tree-tomato-production/

Tufan Ekrem and et al. (2017). International Conference on Economics and Administration. August, 133–141.

Ullah, N, Ullah S, Khan A, Ullah I, and Badshah S. (2018). 'Preparation and Evaluation of Carrot and Apple Blended Jam'. *Journal of Food Processing & Technology* 09(04). https://doi:10.4172/2157-7110.1000725

UNICEF. 2016. 'Kakamega County, Kenya Multiple Indicator Cluster Survey 2013/14'.

Vasco, C., Avila, J., Ruales, J., Svanberg, U., & Kamal-Eldin, A. (2009). Physical and chemical characteristics of golden-yellow and purple-red varieties of tamarillo fruit (Solanum betaceum Cav.). International Journal of Food Sciences and Nutrition, 60(SUPPL. 7). https://doi.org/10.1080/09637480903099618

Wallace, T. C., Bailey, R. L., Blumberg, J. B., Burton-Freeman, B., Chen, C. y. O., Crowe-White, K. M., Drewnowski, A., Hooshmand, S., Johnson, E., Lewis, R., Murray, R., Shapses, S. A., & Wang, D. D. (2020). Fruits, vegetables, and health: A comprehensive narrative, umbrella review of the science and recommendations for enhanced public policy to improve intake. *Critical Reviews in Food Science and Nutrition*, *60*(13), 2174–2211. https://doi.org/10.1080/10408398.2019.1632258

Wang, S., & Zhu, F. (2020). Tamarillo (Solanum betaceum): Chemical composition, biological properties, and product innovation. In Trends in Food Science and Technology (Vol. 95). https://doi.org/10.1016/j.tifs.2019.11.004

Whitehead, D., & Whitehead, L. (2016). Sampling data and data collection in qualitative research methods. Nursing and Midwifery Research, March 2019, 111–126. http://dx.doi.org/10.1016/B978-0-7295-4230-2.00007-9

WHO. 2013. 'WHO Guideline 1'. *Review Literature and Arts of The Americas* 1.

WHO. (2006). Multicentre Growth Reference Study Group . *WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development.* Geneva.

Yeasmin, Fahmida & Khan, Md. Junaeid & Riad, M.H. (2020). Evaluation of quality characteristics and storage stability of mixed fruit jam. Food Research. 5. 225-231. http://doi.org/10.26656/fr.2017.5 (1).365

APPENDICES

APPENDIX 1: CHILD QUESTIONNAIRE

Personal information

Date ……. Month ……... Year……

Childs Identity No…….... Sub location ……... Village……

Name of preschool ……

Demographic data

Gender of the child; Male ☐ Female ☐

Nutrition assessment

Weight…… (Kgs) Height…… (cm) MUAC…… (cm)

Clinical signs

Clinical Sign	Description
Colour of the hair	
Colour of the eyes	
Skin colour	
Colour of the nails	
Colour of the lips	
Allergic reactions	

Tamarillo honey jam consumption

Have you been using jam before? Yes ☐ No ☐

Where have you been buying your jam from? Shop ☐ Supermarket ☐ Wholesale ☐

Other

……

Sensory evaluation of jam

On a scale of 1-5, how do you qualify the above jam?

Parameter	1 Like extremely	2 Like very much	3 Like moderately	4 Like slightly	5 Neither like nor dislike	6 dislike slightly	7 Dislike moderately	8 Dislike very much	9 Dislike extremely
Appearance									
Smell									
Taste									
Mouth feel									
Fluidity									
Acceptability									

APPENDIX II: FOCUS GROUP INTERVIEW

Respondent's information

Number of participants

……
……
……...

Group composition (gender, age, educational background, marital status)

……
……
……
……
……
……

List of Respondents;

Respondents

……
…….

Before the discussion

Inform respondents about the purpose and goal of the focus group discussion.

Stress confidentiality to ensure that respondents' details, ideas and insights will be kept for the purpose of the focus group discussion.

Have respondents introduce themselves to the group.

Discussion

.....
.....
.....

How familiar are you with our product?

.....
.....
.....

When you see our product, what is the first thing that comes into your mind?

.....
.....
.....

What influences you to buy our product?

.....
.....
.....

What are the things you like about our product?

.....
.....
.....

What are the things you don't like about our product?

.....
.....
.....

If we are to change anything about our product, what will that be?

.....

.....

.....

Will you recommend our product to your friends and family? Why or why not?

.....

.....

.....

Completion

Name ……..

Signature of Focus Group

Moderator.....

APPENDIX III: INFORMED CONSENT

Masinde Muliro University of science and Technology parental permission to participate in the research.

Study Title : Development, nutrient composition and acceptability of tamarillo honey jam among preschools (4-5) years and adults (Parents and teachers) (25-60) years in Lurambi sub county, Kakamega.

Researcher : Asianut Opo Dorcas

Dear parent,

This is a parental permission form for research participation. It contains important information about this study and what to expect if you permit your child to participate. Your child's participation is voluntary. Please consider the information carefully. Feel free to discuss the study with your family and to ask questions before making your decision whether or not to permit your child to participate. If you consent, you will be asked to sign this form on the last page and will receive a copy of the form. If you are uncertain about any part of this form or unclear on what the research study is or what it requires, please contact Asianut Opo Dorcas, +254702604803/dasianut91@gmail.com.

Purpose

The purpose of this study is to collect information on your child's intake of jam that you will be provided with. As a research team, we are trying to establish the sensory attributes of the jams and also determine the nutritional status of your child before and after consumption of the jam after taking you through the necessary steps.

Procedures/Tasks

Your child will be participating in the sensory attributes acceptability exercise daily. This will only include the snacking times 10a.m and 4p.m. and will not interfere with normal school or home timetable. As part of the study, your child will be provided with a tin of jam and you will be asked to complete a short survey on his sensory evaluation based on his responses. You will be required to probe the responses from your child.

Duration

The duration of the study, including collection of this parental consent form, child assent, and demographic surveys, dietary recalls, and lessons, will take place over 8 weeks: May – June, 2021. Your child may leave the study at any time. If you or your child decides to stop participation in the study, there will be no penalty and neither you nor your child will lose any benefits to which you are otherwise entitled. Your decision will not affect your future relationship with The University.

Risks and Benefits

There are minimal risks to participate in this study. By participating in this program, your child will be part of nutrition intervention and implementation program through the use of nutritious and healthy developed product. Your child will also benefit by gaining valuable knowledge about best spreads and how to make healthy and informed dietary choices. The research team will ensure necessary information on filling the questionnaire is provided to avoid misinformation and biasness.

Confidentiality

Efforts will be made to keep your child's study-related information confidential. The research team makes every effort to ensure the answers your child provides are not shared outside of the research team. In addition, the questionnaires will be assigned serial numbers linked to the child's responses and the identity of the child will not be disclosed.

Contact person

For any questions, complaints or enquires concerning the study, or your child being harmed as a result of the study, contact Asianut Opo Dorcas at dasianut91@gmail.com or +254 702 604 803

Respondents Consent

I have read and understood this form, (or someone has read to me) this form and I am aware that I am being asked to consent for my child to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to permit my child to participate in this study. I am not giving up any legal rights by signing this form. I will be given a copy of this form.

Yes ☐ No ☐

Signature…… Date……

Researcher/ investigator statement

I have explained the research to the parent of the participant in the clearest manner and language, the procedures, risks and benefits of the study.

Name of Investigator……..

Signature…… Date……

APPENDIX IV: RESEARCH PERMIT, NACOSTI

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **320884**

Date of Issue: **10/November/2021**

RESEARCH LICENSE

This is to Certify that Miss.. Dorcas Opo Asianut of Masinde Muliro University of Science and Technology, has been licensed to conduct research in Kakamega on the topic: DEVELOPMENT, NUTRIENT COMPOSITION AND ACCEPTABILITY OF TAMARILLO HONEY JAM AMONG PRESCHOOLS (4-5) YEARS AND ADULTS IN LURAMBI. for the period ending : 10/November/2022.

License No: **NACOSTI/P/21/14247**

320884

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

APPENDIX V: MMUST IERC RESEARCH PERMIT

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY

Tel: 056-31375
Fax: 056-30153
E-mail: ierc@mmust.ac.ke
Website: www.mmust.ac.ke

P. O. Box 190,
50100.
Kakamega,
KENYA

Institutional Ethics and Review Committee (IERC)

REF: MMU/COR: 403012 Vol 5 (01)

Date: November 04th, 2021

To: Ms. Dorcas Opo

Dear Madam,

RE: DEVELOPMENT, NUTRIENT COMPOSITION AND ACCEPTABILITY OF TAMARILLO HONEY JAM AMONG PRE-SCHOOLS (4-5) YEARS AND ADULTS IN LURAMBI.

This is to inform you that ***Masinde Muliro University of Science and Technology Institutional Ethics and Review Committee (MMUST-IERC)*** has reviewed and approved your above research proposal. Your application approval number is **MMUST/IERC/028/2021.**The approval period is ***November 04th, 2021-November 04th, 2022.***

This approval is subject to compliance with the following requirements;

i. Only approved documents including informed consents, study instruments, MTA will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***MMUST-IERC.***
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to ***MMUST-IERC*** within 72 hours of notification
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to ***MMUST-IERC*** within 72 hours
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to ***MMUST-IERC.***

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://research-portal.nacosti.go.ke and also obtain other clearances needed.

Yours Sincerely,

Prof. Gordon Nguka
Chairperson, Institutional Ethics and Review Committee

Copy to:
- The Secretary, National Bio-Ethics Committee
- Vice Chancellor
- DVC (PR&I)

APPENDIX VI: MINISTRY OF HEALTH RESEARCH PERMIT

REPUBLIC OF KENYA

COUNTY GOVERNMENT OF KAKAMEGA
MINISTRY OF HEALTH SERVICES

Telephone: 056-31850/1852/31853
Email: health@kakamega.go.ke
Website: www.kakamega.go.ke

County Director of Health
P.O. Box 36-50100
KAKAMEGA

Ref: No. CGK/MOH/ME/VOL.1/11

Date: 15th February 2022

Dorcas Opo Asianut,
dasianut91@gmail.com

Dear Dorcas;

RE: REQUEST FOR AUTHORIZATION TO CONDUCT A STUDY IN KAKAMEGA COUNTY; DEPARTMENT OF HEALTH

Pursuant to your request to carry out a study protocol entitled:

"Development, Nutrient Composition and Acceptability of Tamarillo Honey among Pre-School (4-5) years and adults in Lurambi, Kakamega County, Kenya."

This is to notify you that we have reviewed your study and ascertained that due procedures have been followed. You have provided the study protocol, a Negative microbiological product report from KEBS (***UID code 202011161756 –VI***), MMUST IERC approval (***MMUST-IERC/028/2021***)- exp. Nov 4, 2022; and NACOSTI license (***NACOSTI/P/21/14247***) exp. NOV 10, 2022. We have established beyond reasonable doubts that the study will not disenfranchise the vulnerable.

Your request has been granted; you shall work closely with the County Nutritionist and MOH Lurambi Sub-County, during the data collection period. At the end of your study, you shall be required to disseminate your study findings and recommendations to the CHMT and the County Director of Health.

Best regards,

Dr. Linet Elamenya,

COUNTY DIRECTOR OF HEALTH SERVICES
17 APR 2022

Ag. Director, Health Services,
Department of Health, Kakamega County

Copy To;
CHMT, SCMOH - Lurambi

APPENDIX VII: KEBS STADARDIZATION MARK

KEBS KEBS KEBS KEBS KEBS KEBS KEBS KEBS KEBS KEBS KEBS KEBS KEBS KEBS KEBS KEBS KEBS KEBS KEBS KEBS KEBS

PERMIT TO USE THE STANDARDIZATION MARK

THE STANDARDS ACT (CAP. 496 OF THE LAWS OF KENYA)

PERMIT IS GRANTED TO :

NAME OF FIRM: CLAZEE ENTERPRISE

POSTAL ADDRESS: P.O BOX 118 SHIANDA

PHYSICAL ADDRESS: KIRDI KIISUMU

TELEPHONE NO.: +254726 936 221 / +254 702 604 803

FAX NO. :

E-MAIL ADDRESS: clazee4@gmail.com & dasianut91@gmail.com

STANDARDIZATION MARK NO. : 54350

EFFECTIVE FROM: 2022-03-23

EXPIRES ON.: 2024-03-22

DATE OF ISSUE: 2022-03-23

to use the standardization mark specified in the first row hereunder upon and in respect of the commodity and brand specified in the second and third rows there of, which commodity, conform to the standard specification in the fourth row.

1	STANDARDIZATION MARK	KEBS STANDARDIZATION MARK
2	DESCRIPTION OF THE COMMODITY UPON WHICH THE STANDARDIZATION MARK IS TO BE USED	TAMARILLO HONEY JAM
3	BRAND NAME	CLAZEE
4	STANDARD SPECIFICATION (Number and Title)	KS 2455 :2013 General standard - Food safety

NOTE: 1. EVERY PERMIT HOLDER SHALL PAY AN ANNUAL FEE IN RESPECT OF EACH PERMIT GRANTED OR RENEWED

2. THIS PERMIT IS ISSUED SUBJECT TO THE CONDITIONS SET OUT OVER LEAF

MANAGING DIRECTOR / AUTHORIZED OFFICER

KENYA BUREAU OF STANDARDS

KEBS Kenya Bureau of Standards

Cert-01

APPENDIX VIII: PROXIMATE AND MICRONUTRIENT ANALYSIS RESULTS

LARBCORPT LABORATORIES & SUPPLIES

LARBCORPT LABORATORIES AND SUPPLIES
P.O BOX 53262-00100, Off
Waiyaki way, upper Kabete

+254 720 118 459
+254 773 853 187

INFO@LARBCORPT.COM
WWW.LARBCORPT.COM

LABORATORY CERTIFICATE OF ANALYSIS

Sample Description: TAMARILLO JAM	**Lab Certificate reference No.LAR CL 001/2022**
Client Name and Location address: CLAZEE ENTERPRISE, P.O. BOX 118-50106, SHIANDA	
Date of Receipt: 5TH SEPTEMBER 2022	**Date of Test report: 9TH SEPTEMBER 2022**
Sample Submitted by: MARTINS SHEGAN	**Sample received by: GEOFFREY OTIENO**
Standard reference /Method: KS 139:2018	
Additional information: Laboratory Analysis	

Test Parameters	Results	Test Method
Moisture content %	21.5	ISO 6496
Crude protein %	0.1	AOAC 2001.11
Fat content %	0.36	AOAC 2003.05
Sugar content %	30.32	Lane-Eynon
Crude fiber %	0.02	ISO 6541
Total ash %	0.22	ISO 936
Carbohydrates %	77.82	FAO, 2003
Zinc Mg/100g	0.03	AOAC 999.10
Iron Mg/100g	0.08	AOAC 999.10
Potassium Mg/100g	0.01	A0AC 999.10
Sodium Mg/100g	1.09	AOAC 999.10
Magnesium Mg/100g	2.3	AOAC 999.10
Vitamin A µg/100g	0.3	ISO 20633
Vitamin E µg/100g	0.2	ISO 20633
Vitamin B µg/100g	0.16	ISO 21470
Vitamin C µg/100g	49.63	ISO 20633
Folate Mg/100g	Not detected	ISO 21470

- **% Percentage Mg/100g: Milligrams per 100 grams.**

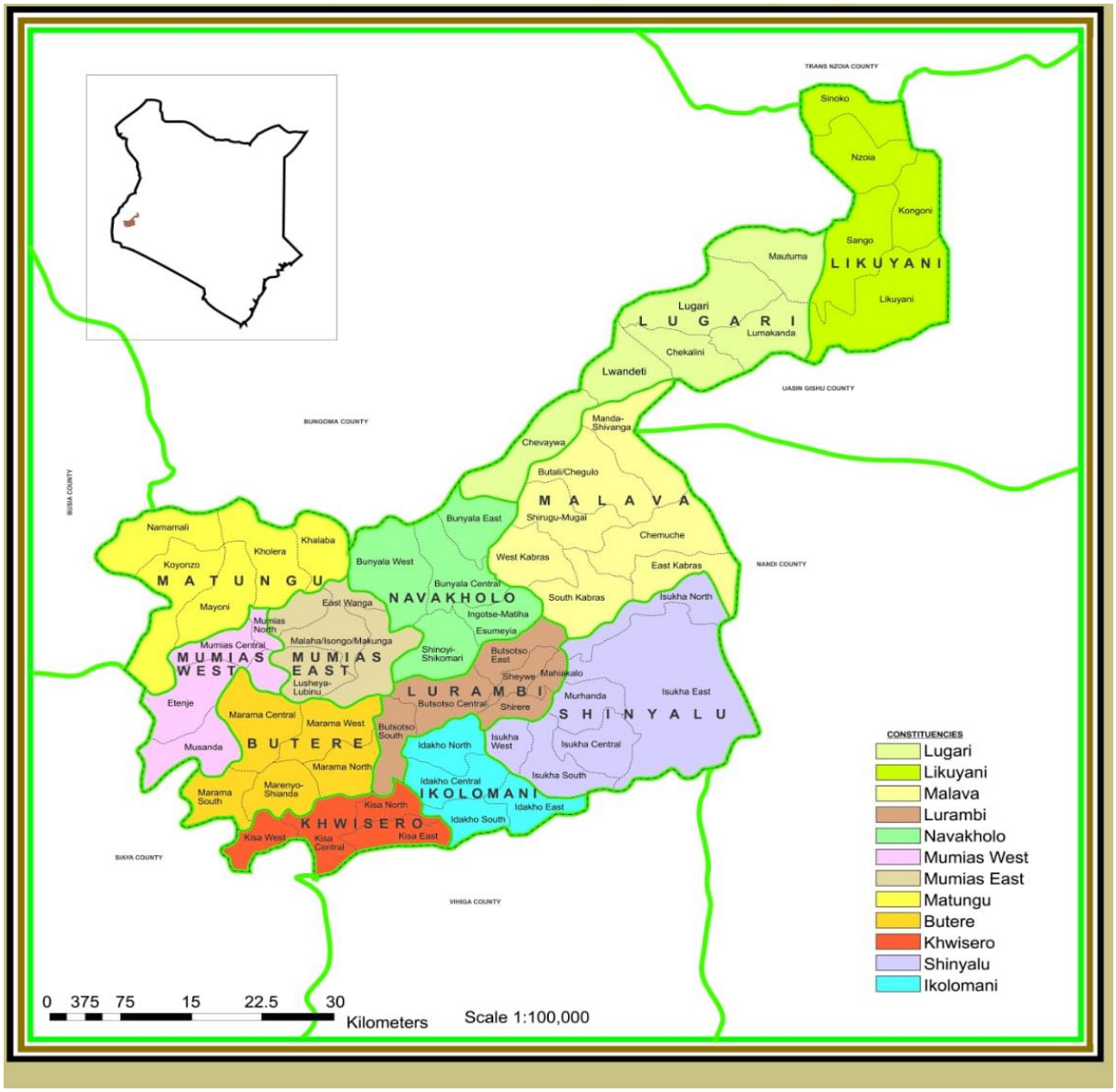
Signature **Signature**

Beatrice Wangoi (Quality Manager) **Rose Kisero (Technical manager)**

End of Page

LAR-FM-01

APPENDIX IX: MAP OF KAKAMEGA COUNTY



APPENDIX X: PICTURES OF TAMARILLO HONEY JAM