

UNIVERSITY OF CAPE COAST

CONSUMER ACCEPTABILITY AND NUTRITIONAL COMPOSITION
OF BEETROOT AND SOURSOP (BEETSOP) JAM



ELIZABETH OPOKU

UNIVERSITY OF CAPE COAST

CONSUMER ACCEPTABILITY AND NUTRITIONAL COMPOSITION
OF BEETROOT AND SOURSOP (BEETSOP) JAM



This thesis submitted to the Department of Vocational and Technical Education of the Faculty of Science and Technology Education, College of Education Studies, University of Cape Coast, in partial fulfillment of the requirements for the award of Master of Philosophy Degree in Home Economics

MARCH, 2026

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature:

Date: 17/03/2026

Name: Elizabeth Opoku

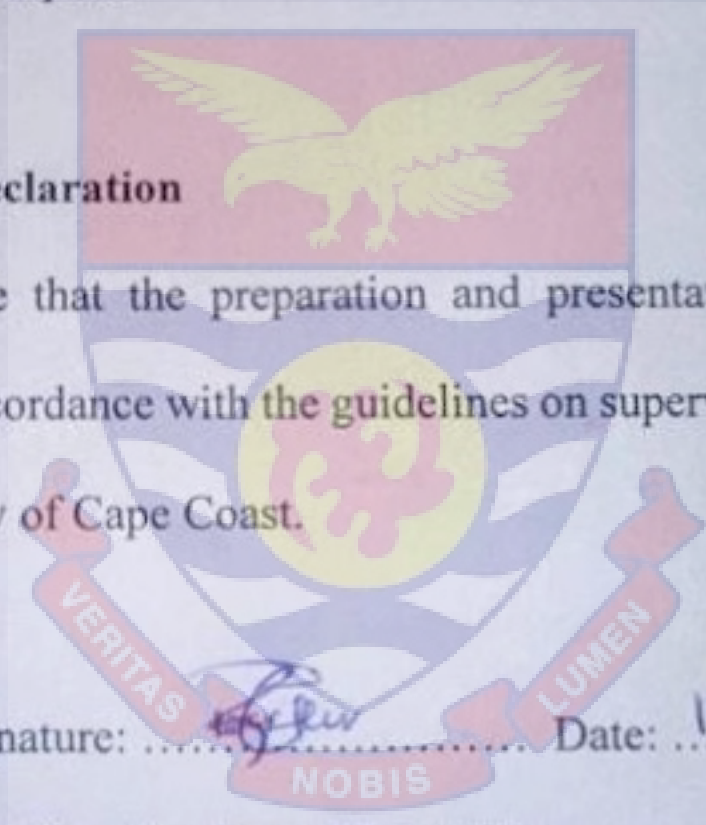
Supervisor's Declaration

I hereby declare that the preparation and presentation of this thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Supervisor's Signature:

Date: 17/03/2026

Name: Dr. (Mrs.) Roseline Love MacArthur.



ABSTRACT

The study aimed to develop a beetroot-soursop jam (BeetSop) and evaluate its nutritional composition, sensory properties, and shelf life. An experimental design was adopted, and purposive sampling was used to select 80 panellists for sensory evaluation. Standard AOAC protocols were employed for proximate, mineral, and microbial analyses, while sensory evaluation followed a 5-point hedonic scale. Three formulations were developed: Beetroot with Soursop (BWS), Soursop with Beetroot (SWB), Beetroot and Soursop (BAS). The control was Black Plum Jam (BPJ; control). Results showed that the BWS formulation achieved the highest acceptability score (mean: 2.34 ± 0.83) and favourable nutritional profile, with high carbohydrate ($83.00 \pm 0.18\%$) and fibre content ($6.20 \pm 0.03\%$). SWB exhibited the highest mineral content, particularly potassium and phosphorus, while BPJ demonstrated the longest shelf life with minimal microbial growth. The findings indicate that combining beetroot, soursop, and dates can yield a nutrient-dense, appealing preserve with potential as a functional food product.

KEYWORDS

Ash

Constituents

Dry Matter

Mineral

Moist content

Proximate analysis



ACKNOWLEDGEMENTS

I would like to first extend my deepest gratitude to the almighty God who gave me strength to undertake this study. I would like to also express my profound gratitude to Dr. (Mrs.) Roseline Love MacArthur my supervisor for her strict supervision, guidance, and patience during the period of this study. Her mentorship and encouragement enabled me to complete this thesis with less difficulty. I would also want to thank my dear mom, Matilda Agyei Duodu, for her support and motivation.



DEDICATION

To my entire family for their endless support



TABLE OF CONTENTS

	Page
DECLARATION	Error! Bookmark not defined.
ABSTRACT	iii
KEYWORDS	iv
ACKNOWLEDGEMENT	v
DEDICATION	vi
TABLE OF CONTENTS	vii
LIST OF FIGURES	xiii
CHAPTER ONE: INTRODUCTION	1
Background to the Study	1
Statement of the Problem	6
Purpose of the Study	7
Research Objectives	7
Research Questions	8
Research Hypotheses	8
Significance of the Study	9
Delimitation	10
Limitation	10
Organization of the Study	10
CHAPTER TWO: LITERATURE REVIEW	12
Introduction	12
Theoretical Review	12
Cultural and Social Influence Theory	12
Product Development Cycle	13

Conceptual Review	15
Concept and History of Jam	15
The Process of Making Jam	15
Health Benefits of Jam	17
Consumer and Consumers' Acceptability of (Jam) Products	17
Sensory Attributes	19
Health Considerations	19
Packaging and Presentation	20
Market Trends	20
History of Beetroot	21
Description of Beetroot	22
Geographical Distribution of Beetroot	23
Proximate Analysis of Beetroot	24
Uses of Beetroot	25
Benefits of Beetroot	26
Introduction and Description of Soursop	26
Botanical Characteristics of Soursop	27
Physical Attributes of Soursop	27
Growth, Yield and Varieties of Soursop	27
Global Distribution and Cultivation of Soursop	28
Proximate Analysis on Soursop	30
Uses of Soursop	31
Overview of Dates Palms	32
Historical Background of Dates	32
Cultivation and Varieties of Dates	33

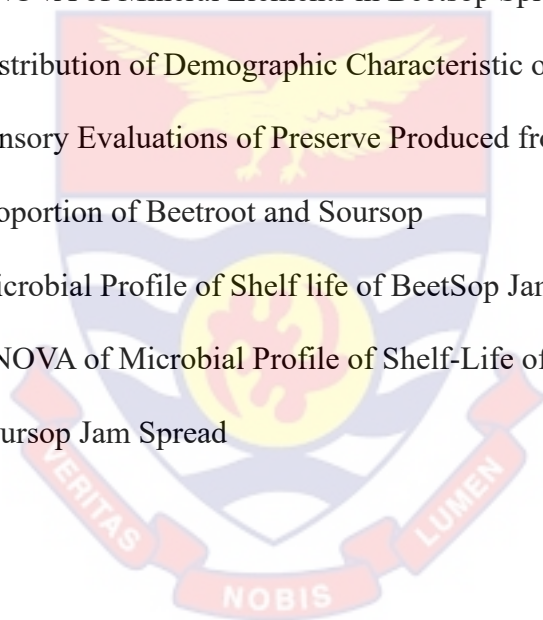
Description of Date Palm	34
Geographical Distribution	35
Proximate Analysis on Dates	36
Uses of Dates	37
Empirical Review	37
The Processes Involved in the Development of Beetroot and Soursop Jam	38
Nutritional Composition of Beetroot and Soursop Jam	43
Consumer Acceptability of the Beetroot and Soursop Jam	45
The Life Span of Beetroot and Soursop Jam Without Any Changes in Quality	
Attributes	46
Gaps and Lessons Learned from the Empirical Review	49
CHAPTER THREE: RESEARCH METHODS	51
Introduction	51
Research Design	51
Study Area	51
Population	52
Sampling Procedure	52
Data Collection Instrument	53
Material and Methods	53
Materials	53
Sample Preparation	54
Preparation of BeetSop Jam	54
Preparation of black plum Jam	54
Data Collection Procedures	56
Nutritional Analysis	57

Proximate Analysis	58
Mineral Analysis	61
Microbial Analysis	63
Shelf life Determination	63
Sensory Evaluation	64
Ethical Clearance and Inclusion Criteria	66
Data Analysis	66
Data Management	67
CHAPTER FOUR: RESULTS AND DISCUSSION	68
Introduction	68
Research Question One: How feasible is the production of jam with beetroot and soursop (BeetSop jam)?	68
Research Question Two: What is the nutritional composition of the BeetSop Jam?	70
Nutritional Composition of BeetSop Jam	70
Research Question Three: To what extent do consumers accept the beetroot and soursop Jam?	85
Consumer Preferences and Overall Acceptability	85
Demographic characteristics of respondents	85
Sensory Evaluation of BeetSop Jam	86
Research Question Four: How long can the BeetSop Jam be kept without sensory quality changes?	91
Shelf-Life and Quality Attributes of BeetSop Jam	91
Aerobic Plate Count	91
Total Coliform	91

<i>Salmonella spp</i>	92
<i>Rhizopus stolonifer</i>	92
CHAPTER FIVE: SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS	97
Overview of the Study	97
Summary of Key Findings	98
Conclusions	99
Recommendations	100
Suggested area for Further Studies	101
REFERENCES	102
APPENDICES	129
APPENDIX A: SENSORY EVALUATION QUESTIONNAIRE	129
INFORMED CONSENT FORM	131
APPENDIX B: CONSENT FORM FOR DISCUSSION	132
APPENDIX C: A VOLUNTEER AGREEMENT	134
APPENDIX D: ETHICAL CLEARANCE	135

LIST OF TABLES

Table		Page
1	Research Objective-analysis	67
2	Major Chemical Constituent of the Three of BeetSop Jam Sample	75
3	ANOVA of Major Chemical Constituent of the Three of BeetSop Preserve Sample	76
4	Mineral Elements Constituent of BeetSop Jam	82
5	ANOVA of Mineral Elements in Beetsop Spread	83
6	Distribution of Demographic Characteristic of Respondent	86
7	Sensory Evaluations of Preserve Produced from Different Proportion of Beetroot and Soursop	90
8	Microbial Profile of Shelf life of BeetSop Jam Samples	95
9	ANOVA of Microbial Profile of Shelf-Life of Beetroot and Soursop Jam Spread	96



LIST OF FIGURES

Figure		Page
1	A bundle of organic beets from a local farm food co-op program	23
2	Soursop fruit	28
3	Date fruit	35
4	Flowchart for the production of BeetSop jam	56
5	Five-point hedonic scale	66



CHAPTER ONE

INTRODUCTION

Background to the Study

Consumer interest in functional foods and natural fruit-based spreads is growing globally, and particularly in Ghana, due to rising health awareness and dietary transitions toward nutritious, minimally processed products (Baker et al., 2022; Mitrevski et al., 2023). However, Ghana currently lacks locally produced fruit-based spreads in its market, despite the country's rich fruit production and strong governmental focus on value-added food processing (Kongor et al., 2024; Mitrevski et al., 2023). The domestic fruit and vegetable market in Ghana is projected to reach USD 1.01 billion in 2023, with steady growth expected through 2030 (Kongor et al., 2024).

National agricultural policies, including the Food and Agriculture Sector Development Policy, Medium-Term Agriculture Sector Investment Plan, and flagship programmes such as Planting for Food and Jobs (PFJ) and the “One District, One Factory” initiative, emphasize food security, nutrition-sensitive value chains, and industrialization through agro-processing (Seremet et al., 2020). Despite such strategies, only a modest fraction of Ghana's agricultural focus has been devoted to producing diverse, nutrient-rich processed foods beyond juices, jams, or dried products (Baker et al., 2022; Eusala & Pendon, 2016).

Nutrition-sensitive food system assessments highlight persistent challenges in access to micronutrient-dense foods, over 65% of Ghanaians cannot afford a healthy diet, underscoring the need for innovative approaches to enhance both nutrient availability and affordability (Araujo et al., 2016;

Baker et al., 2022). Ghana's domestic fruit processing sector continues to rely largely on minimal processing, such as juicing and drying, value-added operations like spreads, jellies, and preserves remain limited, despite demonstrated growth potential and government support (Baker et al., 2022).

In corporate operations, workplace environment, or external relations, innovation is used in the introduction of a new or considerably improved product (item or service), process, marketing approach, or organizational strategy (Bloch, 2007; Ingle et al., 2017). Making food more wholesome and nutritious is one way to innovate the food industry (Chen et al., 2021). Food innovation also aims to meet the shifting demands of the consumer. To address global issues, businesses use innovation. Consumers are becoming increasingly conscious of the ingredients in their food and the processes used in its production (Bangar et al., 2022; Tuorila & Hartmann, 2020).

Numerous epidemiological studies have determined a link between regularly consuming particular nutrients found in fruits and vegetables and the low incidence of developing certain chronic diseases (Knekt et al., 2002; Kongor et al., 2024). Most fruits and vegetables provide most of the micronutrients and, when consumed sufficiently, supply a person with the micronutrients they need. Food can be considered "functional" if it can be successfully demonstrated to affect one or more target biological processes in a way that is significant to either an improved state of health and wellbeing or a lowered risk of disease, in addition to having adequate nutritional effects (Azimont, & Araujo, 2014; Henry-Unaeze, 2021).

More adaptable food innovation is required for the food system to become more sustainable and healthful due to the world's growing complexity

and dynamics in general, as well as the food system in particular (Godfray et al., 2010). Innovation in the food industry has long been a crucial topic, according to Porter (2007), technology breakthroughs and improved procedures or methods of doing things are both components of innovation (Beckeman & Skjöldebrand, 2007). It can come in the form of altered goods, altered manufacturing procedures, altered marketing plans, altered distribution schemes, and altered scope ideas and these describes several levels of innovation, from radical to incremental (Garcia, & Calantone, 2002). The position of consumer acceptability of food innovation has grown increasingly pertinent during periods of abundance, there has been a movement in recent years from market push toward market-driven, consumer-oriented, and even co-creation (Grunert & Trijp, 2014).

Beetroot is a member of the *Beta vulgaris L. genus*. The Beta genus of plants is said to have originated in North Africa and expanded along the Mediterranean Sea route, colonizing the seashores of Europe, Asia, and the Americas (Neelwarne, 2012). Beetroot contains strong therapeutic qualities that have some beneficial effects on the human body. Beets can be consumed fresh, cooked, steamed, or roasted. Magnesium, manganese, sodium, potassium, iron, and copper are among the abundant minerals found in red beetroot (Mathangi, & Balasaraswath, 2019).

Red beetroot is a beloved and commonly consumed vegetable in various cultures worldwide. It is most commonly referred to as "beet." This vibrant root vegetable is a key ingredient in traditional dishes like borscht, vinaigrette salad, Russian "herring under fur" salad, and pickled cabbage with beetroot. It holds a

special place in the hearts of people in Eastern and Central Europe, where it is particularly popular (Jasmitha, et al., 2018; Neelwarne, 2012).

An exotic fruit native to tropical regions, soursop (*Annona muricata*) is also referred to by the names graviola, guanabana, sauersak, guayabano, and other local names in the producing countries (Badrie, & Schauss, 2010). The Caribbean and the Americas' equatorial belt, including the Bahamas, Bermuda, Cuba, Dominican Republic, Grenada, Mexico, Costa Rica, St. Vincent, Puerto Rico, Colombia, Venezuela, Equator, and Brazil, are among the regions where it is economically significant and growing. Mexico is the world's top producer, and it is found across the tropics, including the Caribbean, Africa, and Southeast Asian nations like Thailand, Malaysia, Indonesia, and the Philippines (Coria-Téllez, et al., 2018).

The soursop fruit, known for its distinctive characteristics, thrives in hot climates and is found in various regions including the United States, Europe, India, and Africa. This fruit is characterized by its bright green, spiky, and spherical appearance, while its taste profile is described as a combination of creamy, sweet, and sour flavours (Gyesi et al., 2019). The fruit encompasses a diverse range of 119 species worldwide. Currently, seven species and one crossbreed are cultivated globally for domestic consumption (Sánchez et al., 2018). Among consumers, the soursop fruit is highly favoured for its pleasant and sweet flavour. However, due to the fruit's delicate nature, it is often processed into pulp, which becomes the most commercially valuable form of the fruit and present lucrative opportunities for the commercial sector (Sacramento et al., 2003).

Polyphenols found in soursop plants possess organic properties that act as antioxidants, safeguarding cells against damage caused by free radicals (González, Fernandez, Sáyago-Ayerdi, Estrada, & Vallejo, 2017). These phytochemicals have been utilized in herbal medicine for an extensive period, offering potential benefits in treating various conditions such as infections caused by germs or parasites, fever, high blood sugar, high blood pressure, inflammation, anxiety, and even cancer (Afzaal et al., 2022). Soursop extract exhibits a range of beneficial activities, including antibacterial, anti-protozoan, anti-inflammatory, antioxidant, and anticancer properties (Gyesi, Opoku, & Borquaye, 2019). The presence of these bioactive compounds in soursop highlights its potential as a natural source for developing various nutritious food products and therapeutic treatments targeting various health conditions.

One of the earliest recognized and domesticated tropic and subtropical plant species is the date palm (*Phoenix dactylifera*), which is part of the family Palmae (Arecaceae) and are the most significant subsistence crop in Northern Africa and the Middle East, though they are also grown in other regions of the world (Al-Shahib and Marshall, 2003). The whole date fruit is mostly consumed and used as a thickener, gelling or sweetening agent in dessert and confectionery formulations. Date can be used in the production of jams, yoghurt, fruit juice, and fermented beverages (wine, vinegar, etc.) (Aydeniz-Güneşer, 2022).

Likewise, the date palm (*Phoenix dactylifera*) holds the distinction of being one of the earliest recognized and domesticated plant species in tropical and subtropical regions. Belonging to the Palmae family (Arecaceae), date palms are particularly significant as a subsistence crop in Northern Africa and the Middle East, although they are also cultivated in other parts of the world

(Al-Shahib and Marshall, 2003). Dates are consumed in their entirety and serve various purposes in culinary applications. They are commonly used as a natural thickener, gelling agent, or sweetener in the preparation of desserts and confectionery products. Additionally, dates find utility in the production of jams, yoghurt, fruit juices, and fermented beverages such as wine and vinegar (Aydeniz-Güneşer, 2022). Due to their versatility and sweet flavour, dates have become an integral ingredient in a wide range of food and beverage formulations.

Statement of the Problem

Fruits are perishable, and to preserve them, they are often converted into juices, jams, and marmalades (Magnuson et al., 2013). Traditional jams are typically made with high amounts of sucrose, which acts as a preservative by absorbing water and inhibiting microbial growth (Smyth & Heron, 2006; Clarke, 1997). However, excessive sucrose consumption is linked to obesity and other health issues, including type 2 diabetes (Lenoir & Ahmed, 2007; Jribi & Debbabi, 2021).

Despite the numerous health benefits of beetroot and soursop, their potential uses in jam production have not been fully explored. Beetroot is known for its anti-inflammatory, antioxidant, and health-promoting properties, while soursop has demonstrated antimicrobial, anti-inflammatory, and anticancer properties (Georgiev et al., 2010; Clifford et al., 2015; Leatemia & Isman, 2004).

Currently, there are no jam products combining beetroot and soursop. Considering the widespread of cancers in recent times, harnessing the synergistic benefits of beetroot and soursop, and dates due to their antioxidant

properties, nutrients profile, and therapeutic phytochemicals, respectively, will offer a functional food product that can contribute positively to consumer health by preventing or managing various cancers (Maqsood, Adiamo, Ahmad, & Mudgil, 2020). Also, using dates as a natural sweetener in jam production offers a healthier alternative, as fructose from dates is released into the bloodstream more gradually, thus lowering glycemia in both healthy and hyperglycaemic individuals (Younas et al., 2020).

While several studies have examined beetroot or soursop based products individually, there is little to no research on combining these two nutrient-rich ingredients into a single spread. This gap presents an opportunity to explore a novel formulation that merges their complementary health benefits, antioxidant properties, and unique flavours. The present study seeks to address this gap by developing and evaluating a beetroot–soursop jam, thereby contributing new insights to functional food innovation and expanding healthy spread options for consumers.

Purpose of the Study

The purpose of the present study was to produce innovative and nutrient rich spread from beetroot and soursop spread using date powder as a healthy sweetener.

Research Objectives

The study sought to:

1. determine the feasibility of producing a preserve with beetroot and soursop (BeetSop preserve).
2. analyse the nutritional composition of the BeetSop preserve.

3. assess the level of consumer acceptance towards the beetroot and soursop preserve.
4. determine the shelf life of the BeetSop preserve without any sensory quality changes.

Research Questions

The study was guided by the following research questions

1. How feasible is the production of preserve with beetroot and soursop (BeetSop preserve)?
2. What is the nutritional composition of the BeetSop preserve?
3. To what extent do consumers accept the beetroot and soursop preserve?
4. How long can the BeetSop preserve be kept without sensory quality changes?

Research Hypotheses

H₀₁: There is no significant difference in the proximate and mineral composition among the different formulations of the BeetSop preserve.

H₁₁: There is a significant difference in the proximate and mineral composition among the different formulations of the BeetSop preserve.

H₀₂: There is no significant difference in consumer sensory acceptability ratings between the BeetSop preserve and traditional jam samples.

H₁₂: There is a significant difference in consumer sensory acceptability ratings between the BeetSop preserve and traditional jam samples.

H₀₃: There is no significant change in the sensory and microbial quality of the BeetSop preserve during storage within the determined shelf-life period.

H₁₃: There is a significant change in the sensory and microbial quality of the BeetSop preserve during storage within the determined shelf-life period.

Significance of the Study

Exploring the consumer acceptability and nutritional composition of a unique product like "BeetSop jam" - a blend of beetroot and soursop in a preserve is crucial for several reasons. Firstly, BeetSop Preserve represents an innovative culinary creation, merging the distinct flavours and nutritional benefits of beetroot and soursop into a singular, shelf-stable product. This fusion warrant investigation into how consumers perceive and embrace this novel offering.

Moreover, both beetroot and soursop possess noteworthy nutritional profiles, replete with essential vitamins, minerals, and bioactive compounds. By studying the nutritional composition of BeetSop jam, we can gain insights into the concentration and preservation of these beneficial elements, potentially uncovering its role in promoting health and well-being.

Furthermore, in the context of dietary diversity and convenience, BeetSop Preserve emerges as a convenient means to incorporate the goodness of beetroot and soursop into everyday meals. Its long shelf life and versatility make it a promising addition to the existing preserves thereby diversifying culinary preferences and dietary needs.

Considering the functional food perspective, BeetSop jam may offer not only sustenance, but also potential health-enhancing properties attributed to its nutrient-rich ingredients. Understanding its nutritional composition can illuminate the extent to which these health benefits are retained through the preservation process.

From a market perspective, investigating consumer acceptability provides valuable insights into the potential demand and preferences for

BeetSop jam. Positive feedback can inform marketing strategies and product positioning, facilitating its successful integration into the marketplace.

Lastly, BeetSop jam aligns with sustainability goals by repurposing surplus or underutilized produce into a value-added product with an extended shelf life. This aspect contributes to efforts aimed at reducing food waste and promoting sustainable food practices. Also, the findings of this research will open an avenue for industry players by providing basis for the successful development of the preserve.

Delimitation

The study essentially explored the possibility of innovating a jam from beetroot and soursop using dates powder as a sweetener and focusing on the nutritional composition and the shelf life of the product. This research was delimited to nutrient composition of the spread to protein, calcium, carbohydrate, fat, magnesium, potassium, sodium, iron, copper and ash. Panel members who were used for sensory evaluation of the developed product comprised of people who are not allergic to beetroot, soursop and date. However, those who are not fit among the group identified will be excluded.

Limitation

Students at the University of Cape Coast, who may not completely represent the entire university student population in Ghana was the only group used for the sensory evaluation of the developed product. With the availability of funds, the stated limitation will be mitigated by conducting a pretest outside the University of Cape Coast and the outcomes will be compared to know whether there will be a difference in the response or not.

Organization of the Study

The study was classified into five chapters. The study's background, problem statement, purposes, significance, delimitation, and limitation were highlighted in the introduction of Chapter One. The second chapter focused on the review of existing literature relevant to the study. The chapter reviewed research on the nutritional value of soursop and beetroot. Different kinds of jam spread, their nutritional makeup, and how to sensory evaluate a product were also covered in this part. The approach that was used for the study to accomplish its stated goals was covered in chapter three which focused on research design, study area, study subject, and research design. It also covers data collection instrument, data collection procedure, analysis and interpretation of the collected data, and ethical considerations.

The analysis and presentation of study data were covered in Chapter Four. The data on the spreads' nutritional composition and microbial analysis as well as the results of the sensory analysis of the test samples were presented in the first section of the chapter. Chapter Five summarized the research's findings, conclusions, recommendations, and suggested some areas for further study.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter dealt with empirical evidence on beetroot, soursop and dates. Similarly, the concept of jam and consumers' acceptability was reviewed. This chapter also discussed the history, plant descriptions, geographical distribution, proximate analysis and uses of beetroot, soursop and dates.

Theoretical Review

Cultural and Social Influence Theory

Cultural and Social Influence Theory explores how cultural norms, traditions, and social context shape individual food choices and acceptance. This theory posits that food choices are deeply embedded in cultural identity and social interaction, with social modelling, descriptive norms, and conformity driving consumption patterns (Salmani et al., 2020; Urala & Lähteenmäki, 2007). In the context of developing a Beetroot–Soursop–Dates jam, understanding Ghanaian food culture and social acceptance of novel fruit spreads is critical: consumers are likely influenced by what is considered acceptable or desirable within their cultural and peer groups. Social identity and perceived norms may affect whether individuals view BeetSop as familiar, healthy, or aligned with local dietary practices. This framework is particularly useful in understanding how local food traditions, social sharing practices, and group expectations shape acceptance. Prior research applying this principle includes studies showing that perceived eating norms significantly influence food intake and behaviour (Chen, 2011), and that cultural capital and social stratification influence food choice and rejection (Urala & Lähteenmäki, 2007).

Therefore, Cultural and Social Influence Theory provides the sociocultural lens necessary to assess how Ghanaian values and social norms might shape acceptance of a functional, locally innovative spread.

Product Development Cycle

The Product Development Cycle (PDC) is a structured framework that outlines the stages a product passes through from conception to market launch and eventual evaluation. In the context of food innovation, the PDC typically includes stages such as idea generation, concept development, prototype formulation, consumer testing, refinement, and commercial release (Urala & Lähteenmäki, 2007). This systematic approach ensures that product development is grounded in consumer needs, technical feasibility, and quality assurance. For the present study on the Development of a Beetroot–Soursop–Dates jam, the PDC is particularly relevant as it provides a roadmap for moving from identifying a market opportunity, healthier, nutrient-dense spreads in Ghana, through formulating and refining the product, to evaluating its sensory and nutritional qualities. This framework has been successfully applied in food innovation research, such as Benner (2005), who demonstrated its utility in guiding functional food product launches.

Consumer Acceptance Model

The Consumer Acceptance Model for functional foods posits that the acceptance of such products is determined by a combination of product-related factors (e.g., taste, appearance, health claims), consumer characteristics (e.g., health awareness, demographic attributes, prior knowledge), and contextual purchasing influences (e.g., cultural norms, market availability) (Kongor et al., 2024). In the case of the Beetroot-Soursop-Dates jam, this model is useful for

interpreting sensory evaluation results in relation to consumer behaviour. For example, product characteristics such as the jams vibrant colour, natural sweetness from dates, and perceived health benefits are likely to influence consumer perceptions and willingness to adopt the product. Similarly, consumer awareness of beetroot and soursop's health benefits, and growing concerns about excessive sugar intake in Ghana, provide a contextual backdrop that shapes acceptance. Previous studies, such as Baker et al. (2022), have applied this model to understand functional food adoption and found that consumer education and perceived health benefits are critical determinants of acceptance. By incorporating this theoretical lens, the study can better explain the relationship between sensory attributes, health awareness, and consumer adoption potential.

These three theories together provide a comprehensive framework for understanding and guiding the development and acceptance of the Beetroot–Soursop-Dates Preserve. The Product Development Cycle ensures a systematic, process-driven approach to creating and refining the product, covering technical and methodological aspects. The Consumer Acceptance Model offers insights into the individual decision-making processes that determine whether consumers will adopt the product, focusing on sensory attributes, perceived health benefits, and consumer knowledge. The Cultural and Social Influence Theory explains how collective norms, traditions, and social relationships influence acceptance, ensuring that cultural fit is considered alongside product quality.

Conceptual Review

Concept and History of Jam

Jam is a delectable spread made by cooking fruits with sugar to create a thick and sweet preserve (McNamee, 2015). It is a beloved addition to breakfast tables, pastries, and snacks, offering a burst of flavour and a touch of indulgence (García-Martínez et al., 2002). The concept of jam has a rich history, rooted in the preservation of fruits and the desire to enjoy their flavour all year round. According to DeGregorio (2007), jam production a centuries-old technique, has its origins profoundly linked with fruit preservation. The history of preparing fruit preserves extends back to ancient times. Woodroof (1986) asserts that sun-drying was the earliest method of processing fruits, with figs, grapes, and dates grown in ancient Canaan and Egypt.

Ancient Greeks and Romans cooked fruits with honey or grape juice to create a thick, sweet substance for extended storage, extending fruit preserves' lifespan beyond a few weeks post-harvesting (Bowler, Loh, & Marsh, 1995). During the Middle Ages, jam-making techniques spread across Europe, with sugar becoming a common ingredient. Sugar enhanced flavour and served as a natural preservative, allowing fruits to be enjoyed long after their harvest season (Zhu, Liu, Li, & Tian, 2013). The popularity of jam continued to grow, and it became a staple in households across the globe.

The Process of Making Jam

The process of making jam involves a few simple steps that transform fresh or frozen fruits into a spreadable delight. The primary ingredients required are fruits, sugar, and sometimes pectin, a natural thickening agent found in

fruits. According to Sethi and Sethi (2006), jam production may follow these steps.

1. **Selection and Fruit Preparation:** The fruits are selected, washed, peeled, and chopped or mashed, depending on the desired texture of the jam. Some fruits may require removing seeds or pits before proceeding.
2. **Sugar or Natural Sweetener Addition:** The fruit is combined with sugar or a natural sweetener in a pot or saucepan. The addition acts as a preservative, helps in the thickening process, and enhances the flavours of the jam.
3. **Cooking:** The mixture is heated over medium heat, allowing the sugar to dissolve and the fruits to release their natural juices. As the mixture simmers, it thickens, and the flavours intensify.
4. **Optional Pectin Addition:** Depending on the fruit used and desired consistency, pectin may be added. Pectin helps the jam set and achieve the desired thickness.
5. **Sterilization and Storage:** Once the jam reaches the desired consistency, it is transferred to sterilized jars and sealed. Proper sterilization ensures the preservation of the jam and extends its shelf life.

One of the most appealing aspects of jam is the wide range of fruits and flavour combinations available including strawberry, raspberry, apricot, and blackberry jams (Davidson, 2014). However, the possibilities are endless, and unique flavours like fig, mango, pineapple, and even tomato can be transformed into delightful spreads. Albala (2011) revealed that the choice of fruits and flavour combinations depends on personal preference and availability. Some recipes also incorporate additional ingredients like lemon juice or zest, spices

such as cinnamon or ginger, or even herbs like lavender or mint to add complexity and depth to the flavour profile (Morris, 2004). Similarly, commercial or natural pectin is typically included in jam preparation recipes as a gelling agent (Imbahale, 2020).

Health Benefits of Jam

Jam, when made with high-quality fruits, offers several health benefits. Fruits are naturally rich in essential vitamins, minerals, and antioxidants and these nutrients are concentrated in jam which is crucial for maintaining good health and preventing chronic diseases. (Aksay, Tokbaş, Arslan, & Çınar, 2018). Additionally, the natural sugars found in fruits provide a healthier alternative to refined sugars, making jam a better choice for those looking to reduce their intake of processed sweeteners (Rao, Lalmanpuia, Krishna, & Saloni, 2021). While jam can be a nutritious addition to a balanced diet, it is important to note that moderation is key due to its nature as a sweet spread, and it should be consumed in reasonable quantities to maintain a healthy lifestyle.

Consumer and Consumers' Acceptability of (Jam) Products

A consumer is an individual or organization that purchases and uses a product or service to satisfy their needs, wants, or desires. According to Rajagopal, and Rajagopal (2020), consumers can be individuals, groups such as family, and organizations searching for, purchasing, using, evaluating, and disposing of products and services to satisfy their needs. Consumers play a vital role in the market economy, as their purchases drive demand and influence the production and distribution of goods and services (Văduva, 2016). They are affected by various characteristics such as needs and wants, preferences and tastes, budget and purchasing power, knowledge and awareness of products and

services, cultural and social influences, attitude and behaviours, as well as demographic features including age, gender, income, level of education, and location (Onwezen, Bouwman, Reinders, & Dagevos, 2021; Urziceanu, & Paşcalău, 2016).

Understanding these features of consumers is vital for businesses as it enables the development of effective marketing strategies, the creation of products that align with consumers' needs, and the establishment of robust customer relationships (Wang et al., 2020). In this context, a comprehensive understanding of consumers' needs pertaining to jam, specifically those made from beetroot and soursop, is essential for guiding the selection of the precise quantities of these ingredients required to create an optimal jam spread derived from these fruits.

Consumer acceptability is defined as the degree to which a product, services or experience meets the needs, expectations, and preferences of the target consumers. This phenomenon is noted as crucial aspect of product development and marketing, as it directly influences the satisfaction of customers, their loyalty, and ultimately, a product's success in the market. Several factors influence this acceptability, ranging from sensory attributes to health considerations.

Sensory Attributes

Flavour and Taste

The flavour and taste of a product are primary determinants of consumer acceptability. According to Lawless and Heymann (2010), sensory attributes like sweetness, tartness, and overall flavour profile significantly impact consumer preferences. Consumers tend to have distinct flavour preferences, with some favouring traditional flavours like strawberry and raspberry, while others are more inclined towards exotic flavours such as mango.

Texture and Consistency

Texture and consistency are also critical factors. Ortuno et al (2006) emphasize that the mouthfeel of a product can greatly influence consumer satisfaction. For jams, some consumers prefer a smooth, jelly-like consistency, while others favour a chunkier texture with visible fruit pieces. The spreadability of the jam is another important aspect, as it affects the ease of use in various culinary applications.

Health Considerations

Ingredients and Nutritional Content

In recent years, there has been a growing trend towards healthier food options. Consumers are increasingly concerned about the ingredients in their food, including jams. Organic, low-sugar, and additive-free jams are gaining popularity as health-conscious consumers seek out products that align with their dietary preferences (Grunert, 2005). The presence of natural ingredients and the absence of artificial additives can significantly enhance consumer acceptability.

Dietary Restrictions

Dietary restrictions also play a role in consumer acceptability. For instance, individuals with diabetes may prefer low-sugar or sugar-free jams, while those with food allergies might opt for products free from specific allergens. Understanding these dietary needs and preferences can help manufacturers develop products that cater to a broader audience (Singh-Ackbarali & Maha, 2014).

Packaging and Presentation

Visual Appeal

The packaging and presentation of jam products can significantly impact consumer acceptability. Attractive packaging can draw consumers' attention and influence their purchasing decisions (Srivasta & Bala, 2018). Additionally, the design and colour scheme of the packaging can evoke certain emotions and perceptions about the product, further affecting acceptability.

Convenience

Convenient packaging options, such as squeeze bottles or single-serve packets, can enhance the overall consumer experience. According to Silayoi and Speece (2007), convenience is a key factor in modern consumer behaviour, and products that offer ease of use are more likely to be accepted by consumers.

Market Trends

Artisanal and Gourmet Jams

One notable trend in the jam industry is the rise of artisanal and gourmet jams. These products often feature unique flavour combinations and high-quality ingredients, appealing to consumers who are willing to pay a premium for a superior product (Johnston & Bauman n, 2014). Artisanal jams

are often produced in small batches, emphasizing craftsmanship and attention to detail.

Organic and Natural Jams

There is a growing demand for organic and natural jam products. Consumers are becoming more aware of the potential health risks associated with artificial additives and preservatives, leading them to seek out products made with natural ingredients (Hughner et al., 2007). Organic jams, which are made from fruits grown without synthetic pesticides or fertilizers, are particularly popular among health-conscious consumers.

Consumer acceptability of jam products is influenced by a multitude of factors, including sensory attributes, health considerations, packaging, and market trends. Understanding these factors can help manufacturers develop products that meet consumer expectations and preferences, ultimately leading to greater market success.

History of Beetroot

Mediterranean regions are home to beets even though beetroot has been consumed as a food since the French realized its potential in the 1800s, beetroot leaves have been consumed since before recorded history (Biancardi, et al., 2012). Many meals use beet powder as a colouring additive. Numerous dishes are coloured with beet powder. Some frozen pizzas tint their tomato sauce with beet powder. Although yellow, white, and candle arrow garden beets can be found in specialty markets, deep red ruby garden beets are the most popular variety (Chauhan, Chamoli, & Sharma, 2020).

Sea beets are thought to have come from the Mediterranean shore and were first grown for their palatable leaves, because the foliage resembled squid

tentacles, the Greeks and Romans both cultivated beets for their leaves but also used them as food, giving them the name teutlon and teutlion. (Tařpınar, Öztürk, Altay, & Polat, 2019). By the end of the 15th century, cultivated beet varieties could be found all over Europe and were utilized for both their leaves and their roots (Nottingham, 2004).

Description of Beetroot

Beta vulgaris is an herbaceous biennial or, in rare cases, perennial plant that can grow up to 120 cm (rarely 200 cm) in height and Cultivators are primarily biannual (Misra, & Shrivastava, 2022). The roots of the wild subspecies are brown, fibrous, occasionally swollen, and woody; the roots of the cultivated versions are dark red, white, or yellow and moderately to strongly swollen and fleshy (subsp. *vulgaris*) (Misra, & Shrivastava, 2022). The stems are simple or branching in the upper section, and their surface is ribbed and striate. The stems grow erect or, in the wild varieties, frequently procumbent (Misra, & Shrivastava, 2022). The petioles of the basal leaves are lengthy and may, in certain cultivars, be thickened and red, white, or yellow (Zhu, Mosyakin, & Clemants, 2003).

According to Zhu, Mosyakin, & Clemants, (2003), the simple leaf blade is oblanceolate to heart-shaped, dark green to dark red, slightly fleshy, typically with a pronounced midrib, with whole or undulate edge, and 5–20 cm long on wild plants (sometimes much larger in cultivated species), the blades of the upper leaves range from being rhombic to narrowly lanceolate, and they are smaller and Flowers with dense, spike-like, and basally interrupted inflorescence are formed, the axils of short bracts or the upper portion of the

inflorescence without bracts contain one to three (sometimes eight) flowered glomerulus with tiny flowers.

The urn-shaped, green or reddish-tinged, comprises of five basally connate perianth segments (tepals), 3-5*2-3 mm, five stamens, and a semi-inferior ovary with 2-3 stigmas make up the hermaphrodite flowers, Perianths from nearby flowers frequently merge (Free, Williams, Longden, & Johnson, 1975).



Figure 1: A bundle of organic beets from a local farm food co-op program

Source: Wikipedia

Geographical Distribution of Beetroot

The wild varieties of *Beta vulgaris* are found in North Africa, Macaronesia, Western Asia, southwestern, northern, and southeast Europe along the Atlantic coasts of the Mediterranean Sea (Kadereit, Hohmann, & Kadereit, 2006). Beetroot exists on different continents due to naturalization and are cultivated all over the world in areas with mild winters, they favour very chilly conditions between 15 and 19 °C (Alsabeelah, 2024). The plants can be

found on sandy and rocky beaches, salt marshes, coastal grasslands, coastal cliffs, and other arid or disturbed areas (Romeiras et al., 2016).

Proximate Analysis of Beetroot

A study conducted in India by Dhawan, Sharma, and Scholar (2019) to analysed the nutritional content of 100g of beetroot flour, revealing the following nutrient composition: moisture (6.3g), ash (7.89g), fat (1.53g), crude fibre (5.08g), carbohydrates (77.74g), protein (1.61) g, iron (4.14%), calcium (160.32mg), and vitamin C (4.2mg). Beetroot flour is a rich source of carbohydrates, providing energy and supporting digestive health. Its high fibre content helps maintain regular bowel movements. Beetroot flour is rich in iron, essential for haemoglobin formation and oxygen transport in the blood. It also contains calcium, vital for bone health and muscle and nerve function. Vitamin C is essential for immune function, skin health, and iron absorption from plant-based foods.

Similarly, Bunkar, et al (2020) examined the nutritional values of beetroot powder under different conditions. The results of the study showed that the moisture content ($.52 \pm 0.61\%$ per 100 g of powder) decreased with rising temperature, affecting the product's shelf life and storage stability. Ash content ranged from $4.23 \pm 0.48\%$ to $5.26 \pm 0.51\%$, indicating the total mineral content. Protein content ranged from $1.12 \pm 0.23\%$ to $1.96 \pm 0.43\%$, essential for tissue repair and growth. Fat content ranged from $0.2 \pm 0.05\%$ to $0.28 \pm 0.07\%$, making beetroot flour suitable for low-fat diets. Betalain content decreased with increasing temperature, while total phenolic content (TPC) varied. Iron content varied based on drying methods.

Overall, these studies affirmed beetroot flour as a nutrient-dense ingredient, rich in carbohydrates, fibre, iron, calcium, and vitamin C. It was also shown that the nutritional profile makes it a valuable addition to various recipes, enhancing the overall nutritional content of the cuisine. The variations in nutrient content based on drying methods highlight the importance of processing techniques in preserving the nutritional quality of beetroot flour.

Uses of Beetroot

For culinary purposes

Although beetroots are great when eaten raw, they are more commonly pickled or cooked. You can also eat their leaves, which are referred to as beetroot greens, as a part of salads and soups (Rdn, 2023). Beetroot is also popularly blended as part of smoothies and fruit juices and most children and even some adults do not prefer the raw earthy taste of beets, hence it is normally cooked or boiled (Tnn, 2018).

For medicinal purposes

Beetroots are nutrient-dense and a fantastic source of fibre, iron, potassium, folate (vitamin B9), manganese, and vitamin C and has numerous health benefits, such as enhanced blood flow, decreased blood pressure, and improved exercise performance, have been attributed to beetroots and beetroot juice. (Rdn, 2023). Important pigments called betalains are found in beetroot which have been discovered to possess a variety of anti-inflammatory qualities (Hawkins, 2019).

Also, beetroot juice contains nitric oxide, which improves blood flow to the muscles during exercise and can help your heart and lungs function more efficiently (Fisk, 2023). Beets are abundant in fibre, promoting the growth of

beneficial bacteria in the digestive system, which helps prevent illness and boosts the immune system, moreover, fibre facilitates better digestion and lowers the chance of constipation (Fisk, 2023).

Benefits of Beetroot

Beetroot provides a variety of therapeutic benefits that can help prevent heart disease and some types of cancer (colon cancer) (Moreira et al., 2021) antioxidant, anti-oxidative stress, anti-depressant, anti-cancer, anti-mutagenic, anti-carcinogenic, and radioprotective qualities have been shown by in vitro and pre-clinical research to be among red beet's health advantages (Gadekar, Kadam, & Gokhale, 2016). In addition, beetroot has hematopoietic, antibacterial, anti-inflammatory, diuretic, anti-nephrotoxicity, hepatoprotective, anti-proliferative, immuno-modulatory capabilities, anti-hypertensive, anti-hypercholesterolemia, anti-hyperglycaemic, and anti-hyperglycaemic effects (Singh & Kaur, 2020).

Introduction and Description of Soursop

Soursop, scientifically known as *Annona muricata*, is a tropical fruit that has garnered significant attention due to its unique taste and numerous health benefits, which combine sweetness with acidity (Maheswari & Sinduja, 2020). The fruit comes in various shapes, such as spherical, elongated, or triangular and it belongs to the *Annona* species, commonly referred to as "custard apple," which has been cultivated in many tropical regions for its delicious fruits (George, Kumar, Suresh, & Kumar, 2015). The flesh of soursop can vary in texture, ranging from tender and moist to firm and dry (Chang, Karim, Abdulkarim, & Ghazali, 2018). However, soursop has a short storage life, which poses challenges for its distribution and consumption.

Scientific studies have demonstrated its antibacterial, anti-protozoan, anti-inflammatory, antioxidant, and anticancer activities (Gyesi, Opoku, & Borquaye, 2019).

Botanical Characteristics of Soursop

The soursop tree yields aggregate fruits that are dark green and composed of fused-together berries and related flower elements (Thompson, 2008). The composite soursop fruit can weigh more than 4 kg and is often asymmetrical, irregularly formed, and often oval or heart-shaped (Coronel, 1983). The fruit pulp is made up of white, juicy, fibrous segments that round an extended receptacle (Badrie & Schauss, 2010). Each fertile segment contains one oval, smooth, firm, black seed that is 1.2–2.2 cm in length and fruit may have as few as 5 seeds or as many as 200. The skin is reticulated and has short spines (Morton, 1987).

Physical Attributes of Soursop

The cream-colored interior is granular and easily separates from the mass of white, fibrous juicy segments that encircle the soft pithy centre (Morton, 1987; Badrie & Schauss, 2010). The seedling soursop in Puerto Rico can be broadly categorized as sweet, sub-acid, or acid. These are further separated into round, heart-shaped, oblong, or angular shapes, and then categorized based on the firmness of the flesh, which ranges from tender and moist to stiff and very dry (Morton, 1987).

Growth, Yield and Varieties of Soursop

According to Afzaal et al. (2022), soursop trees typically reach heights of 15 to 20 feet within six years and start bearing fruit within three to five years. Studies conducted on 5-year-old trees in Hawaii reported an average yield of

42.5 kg of fruits per tree during the first harvest, the fruits have a diameter of 15-20 cm and a heart-shaped green appearance. The flesh can exhibit a delicate, juicy texture or a rougher and dry consistency (Afzaal et al., 2022). Over time, soursop has undergone evolution, resulting in the development of more than seven species and several cross-fruits. This evolution has contributed to the diversity in shape, taste, and texture of the fruit, making it a versatile ingredient in various culinary and medicinal applications.



Figure 2: Soursop fruit

Source: Wikipedia

Global Distribution and Cultivation of Soursop

Soursop (*Annona muricata*) is now widely distributed throughout tropical and sub-tropical regions of the world, including India, Malaysia, and Nigeria (Wagner, Herbst, & Lorence, 2017). Historically, it was found in the warmest tropical regions of South and North America. Reports suggest that this plant species is native to tropical America, with a likely origin in Central and northern South America (Wagner et al 2017). Contrary to 17th-century beliefs, archaeological evidence indicates that soursop was one of the first fruit trees

transported from America to the Old-World tropics (Bonavia, Ochoa, Óscar Tovar, & Palomino, 2004).

Soursop is indigenous to the Caribbean, the Dominican Republic, and Brazil. It was introduced to Florida, USA, in 1920 (Santos et al., 2023). Despite its unknown exact origin, soursop thrives in tropical and sub-tropical regions of Central America (Owen, 2018). The fruit is exported to various countries, notably Italy and Nigeria, where it is utilized in the preparation of a wide range of meals, beverages, and herbal remedies, for its edible fruit, *A. muricata* is currently widely grown throughout the Asia Pacific region (Sosef, Hong, & Prawirohatmodjo, 1998).

The date of soursop's introduction to the West Indies and Caribbean region remains unknown., however, Sir Hans Sloane noted its expansion in Jamaica in the early 16th century (Morton, 1987). By 1526, the fruit was reported to be plentiful throughout the West Indies and northern South America (Morton, 1987). The species' presence in literature from Bello, Britton, and Wilson on Puerto Rico and the Virgin Islands suggests it was present in these islands before the 1880s and likely cultivated in Florida since the 1870s (Britton & Wilson, 1924).

Annona species grow at various altitudes, with those having the greatest latitude adaptability also showing the greatest range of adaptation to altitude (Liogier & Martorell, 2000). Despite intensive cultivation, *A. muricata* is found in Puerto Rico and in heavily forested hillsides, mountain forests, and shaded ravines. Optimal growth is achieved in deep, rich, well-drained, semi-dry soils (Orwa, Mutua, Kindt, Jamnadass, & Simons, 2009). Locations with stagnant water should be avoided, even though the species can survive semi-dry soil

conditions, adequate precipitation of 1000mm during the wet season is necessary, as waterlogging can cause floral abscission and root rot (Tripathi, Sankar, & Senthil Kumar, 2014).

The species requires ample light for development, with tropical savannah being the optimum climate for growth, this may explain why it grows more quickly in Nigeria's savannah zone (Pinto, Cordeiro, De Andrade, Ferreira, Filgueiras, Alves, & Kinpara, 2005). In summary, soursop is a fruit of significant interest due to its unique combination of taste, nutritional benefits, and medicinal properties. Its cultivation in tropical regions and its diverse applications make it a valuable fruit in both local and international markets.

Proximate Analysis on Soursop

According to Akomolafe and Ajayi's (2015), the proximate analysis of the soursop seed showed an increasing trend (ash < moisture < carbohydrate < crude fibre < protein < fat), whereas the soursop pulp showed a decreasing trend (carbohydrate > fat > moisture > protein > crude fibre > ash). Although there was a noticeable amount of fat in both, the seed ($37.5\% \pm 1.2$) and pulp ($24.07\% \pm 0.1$) samples, the pulp had a greater carbohydrate content ($32.9\% \pm 0.33$) than the soursop seeds ($25.0\% \pm 0.0$). (Akomolafe & Ajayi's, 2015). The pulp's crude fat content ($24.1\% \pm 0.1$) was higher than (9.8%) readings. The pulp's high carbohydrate content also contributes to its sweet flavour and high energy level. The protein content of the seeds in this study was higher than the value (17.6%) obtained by (Olabinjo, 2019) and the reported protein contents of watermelon (21.5%), orange (20.2%), grape (21.4%) and white roselle (22.7%) seeds (Worrell, Carrington, & Huber, 2004).

Uses of Soursop

For culinary purposes

Soursop is a delicacy which is enjoyed raw; however, people try to switch things up by including it in juices, bread, cake and ice cream. The seeds are considered toxic and must always be discarded (WebMD Editorial Contributors, 2020).

For medicinal purposes

Numerous antioxidants found in soursop, such as vitamin c, phytosterols, tannins, and flavonoids, are beneficial to a person's general health and prevent cell damage (Afzaal et al., 2022). They are also rich in essential vitamins and minerals such calcium, iron, potassium, magnesium, phosphorous, zinc and copper, which are appropriate for the normal functioning of the body (WebMD Editorial Contributors, 2020). According to Hardoko et al. (2015), anti-diabetic properties are shown by *A. muricata*, flavonoids found in it impede the activity of α -glucosidase by forming hydroxylation bonds and substituting at the b-ring and this inhibition stops the breakdown of carbohydrates into glucose and reduces the absorption of glucose, over time, this will stop the blood from accumulating glucose, or hyperglycaemia.

A. muricata's antiprotozoal activity has been investigated in a number of studies, and when its extracts were compared to the common antibiotic streptomycin, they demonstrated antibacterial activity against both Gram-positive and Gram-negative bacteria (Mutakin et al., 2022). According to another research investigation, *A. muricata's* bioactive substances, such as alkaloids, target and destroy the bacterial membrane, including the outer and plasma membranes (Viera et al., 2010).

Another well-known characteristic of *A. muricata* is its ability to heal wounds. According to both macroscopic and microscopic analyses of wounds, two doses of *A. muricata* ethyl acetate extract significantly accelerated wound healing levels (Moghadamtousi et al., 2015). When compared to the vehicle control, wound tissues treated with an ointment containing the acetate extract showed a significant increase in antioxidant levels (Moghadamtousi et al., 2015).

Overview of Dates Palms

The date palm (*Phoenix dactylifera* L.) is a perennial monocotyledonous fruit plant belonging to the Arecaceae family (Barrow, 1998). Renowned for its resilience to environmental challenges, the date palm is a suitable crop for cultivation in arid and semi-arid regions worldwide (Krueger, 1995). Human cultivation and selection of date palms date back to ancient times, blending the lines between wild and cultivated varieties (Krueger, 2001). While *Phoenix dactylifera* is believed to have originated in the Middle East, Western India, and Iraq, wild *Phoenix* species are found in the tropics and subtropics of Africa and Asia (Barrow, 1998).

Historical Background of Dates

The term "dactylifera" derives from the Greek word "dáktulos" (meaning "date") and the Greek verb "ferō" (Rahmani, Aly, Ali, Babiker, & Srikar, 2014). As one of the earliest human-cultivated plants, the date palm has been a source of sustenance for over 6000 years (Abdel Moneim, Abd, & Awad, 2012). There are more than 200 types of dates sold globally, with Egypt, Saudi Arabia, and other Middle Eastern nations being primary producers (Chao & Krueger, 2007). Date cultivation dates to at least 4000 BCE, originating in the

Persian Gulf region, Mesopotamia, and prehistoric Egypt. However, the exact date of origin remains challenging to determine due to the ancient historical context (Chao & Krueger, 2007).

Dates likely originated from western India or ancient Mesopotamia (southern Iraq) around 4000 BC (Meyer & Purugganan, 2013). Pre-Islamic archaeology suggests that the date palm was domesticated in south-eastern Arabia around 2500 BC (Dowson, 1982). Religious texts and literature highlight the ancient significance of dates, with the Nile Valley in Egypt using the date palm frond as a hieroglyphic symbol for a month and the palm itself as a symbol for a year (Dowson, 1982). Date cultivation was practiced in Mehrgarh approximately 7000 BCE and in the Indus Valley between 2600 and 1900 BCE, according to an earlier investigation (Kenoyer & Heuston, 2005). The dates' fruits hold a significant place in religion. During the holy month of Ramadan, dates are used to break the daylong fast in Islam. Jews observe Palm Sunday and consider dates to be one of the seven holy fruits (Al-Shahib & Marshall, 2003).

Cultivation and Varieties of Dates

Date cultivation was practiced in Mehrgarh around 7000 BCE and in the Indus Valley between 2600 and 1900 BCE (Kenoyer & Heuston, 2005). Dates hold a significant place in religious practices, such as breaking the fast during Ramadan in Islam and being one of the seven holy fruits in Judaism (Al-Shahib & Marshall, 2003). In desert regions of North Africa and the Middle East, dates are a staple food crucial to the economy and social life (El-Deek, Attia, & Al-Harhi, 2010). Over 3000 date varieties exist globally, with the most diverse

germplasm found in Iran, Iraq, Morocco, and Tunisia (Almadini, Ismail, & Ameen, 2021).

Description of Date Palm

Date palms, which can grow as tall as 15 to 40 meters, have a fasciculate root system extending up to six meters deep and a cylindrical stem known as the stipe (Chao & Krueger, 2007). The date palm produces 100–120 large fronds, 4–7 meters long, and is a dioecious species with separate male and female plants, the female trees produce about 12 inflorescences annually, with clusters of up to 10,000 blooms (Chao & Krueger, 2007). Date palms start bearing fruit within 2-4 years, reaching full output after 5-8 years, with well-managed palms yielding up to 200 kilograms of fresh dates annually (Daher, Mohamed, & Aberlenc-Bertossi, 2015).

The date fruit is an oblong, one-seeded berry with a sweet and meaty pericarp, varying widely in length, weight, colour, and taste (Chao & Krueger, 2007). Products from the date palm industry include fresh and dried dates, date paste, syrup, and wine. By-products such as cull dates, immature dates, seeds, and molasses are used for animal feed (Daher, Mohamed, & Aberlenc-Bertossi, 2015). Additionally, *Phoenix dactylifera* is an essential agroforestry species, with its trunks tapped for sap to make palm wine and leaves used for thatch, fibre, basketry, and fodder (Daher, Mohamed, & Aberlenc-Bertossi, 2015).



Figure 3: Date fruit

Source: Wikipedia

Geographical Distribution

With 1.15 million hectares of date palm trees cultivated and an average yield of approximately 6.52 tonnes per hectare, the global production of date palm fruits reached 7.52 million tons in 2009. (FAO, 2011). The top producers were Egypt, Iran, Saudi Arabia, the United Arab Emirates, Pakistan, Algeria, Iraq, Sudan, and Oman (FAO, 2011). Arab nations are home to 70% of the world's date palms. In 2007, about 10% of the harvest was exported; the bulk is consumed locally (El-Juhany, 2010). The date palm, one of the first domesticated fruit crops, has been cultivated in desert areas since ancient Egypt around 4000 BC (Ramawat, 2010). Date palm trees are widely distributed in dry and semi-arid areas between 10° and 39° in the Northern Hemisphere; the ideal latitude range for them is between 24 and 34°N in the Old World and between 33 and 35°N on the West Coast of the USA (Zaid & Arias-Jimenez, 2002).

In addition, Pakistan, Australia, Mexico, South America, and South Africa have all received it (Janick & Paull, 2008). Long, scorching summers, little to no rain, and extremely low relative humidity levels throughout the

ripening period are all favourable conditions for date palm growth (Zaid & Arias-Jimenez, 2002). The date palm can be planted anywhere between sea level and 1500 meters above sea level (Daher, Mohamed, & Aberlenc-Bertossi, 2015)

The date palm can endure temperatures as high as 56°C when watered, while 32°C is often the best temperature for growth (Zaid & Arias-Jimenez, 2002). The daily water needs of a date palm tree are 0.21-0.56 m³ (Zaid & Arias-Jimenez, 2002). Irrigation is required if the groundwater supply is insufficient (Daher, Mohamed, & Aberlenc-Bertossi, 2015). The date palm is wind resilient and can withstand strong, hot, dusty, and dry winds, thus, it serves as a wind buffer for plantings that are more delicate and also the date palm tree can tolerate some salinity in the soil, it cannot be classified as a real halophyte because it thrives on sweet soils rather than saline soils (Zaid & Arias-Jimenez, 2002).

Proximate Analysis on Dates

Sani (2015) conducted research to ascertain the therapeutic and nutritional properties of Ajwa dates. The findings were obtained using phytochemical screening and proximate analysis, respectively. For the proximate analysis, fresh dates were utilized, and for the screening of their phytochemical and antioxidant capabilities, aqueous and ethanolic extracts of the dates were employed. Standard procedures were used for all of the analyses. Ajwa dates have 13.3±1.31% moisture content, 3.2±0.10% protein content, 2.0±0.02% ash content, 3.5±0.32% fat content, 11.6±1.89% fibre content, and 66.2±2.67% carbohydrate content, according to the Proximate analysis. The aqueous and ethanolic extracts had substantial concentrations of flavonoids, steroids, and glycosides, as indicated by the phytochemical screening. In the

aqueous extract, there is a moderate amount of phenol and terpenoids, saponins, and phenols and terpenoids are present in moderate amount in aqueous extract while phenol and terpenoid is slightly present in ethanolic extract, but anthraquinones, phlorotannin and tannins are absent in both extracts. Flavonoid concentration is $423\text{mg/g} \pm 0.07$ and $869\text{mg/g} \pm 0.05$ in the aqueous and ethanolic extract respectively. Phenolic content is higher in aqueous extract (160.5 ± 0.71) than ethanolic extract ($53.5\text{mg/g} \pm 2.12$). The date shows greater antioxidant potential in aqueous extract than the ethanolic extract. The proximate analysis and the phytochemical composition of this date have shown that, it has both nutritional and medicinal benefits.

Uses of Dates

For culinary purposes

Dates can be eaten on their own or used as a sweetener in baked goods, smoothies and cereal recipes (Rd, 2023).

For medicinal purposes

Dates are a good source of antioxidants, minerals, and vitamins that promote heart, brain, and digestive health as well as disease prevention (M Abo-El-Saad, & MS Shawir, 2024). There's evidence that dates can facilitate natural birth (Rd, 2023). Dates also contain calcium, phosphorus and potassium, which are some major determinants of the formation of strong and healthy bones and its high fibre content also does wonders for gut health and regulation of bowel activities (Muinos, 2023). It is surprising to note that even though dates are made up of about 70% sugar, they help to control blood sugar. In fact, it is consumed by diabetics with little to no effects (Muinos, 2023).

Empirical Review

The Processes Involved in the Development of Beetroot and Soursop Jam

The study by Rahman and Begum (2022) aimed to formulate a beetroot cream cheese spread that incorporates the health benefits of beetroot into a popular dairy product. The objective was to enhance the nutritional profile and sensory appeal of cream cheese. The process involved blending beetroot puree with cream cheese in varying proportions to determine the optimal formulation. This was followed by evaluating the spread for sensory attributes, including colour, texture, taste, and overall acceptability. The results indicated that the beetroot cream cheese spread not only retained the vibrant colour of beetroot but also enhanced its antioxidant properties, making it a nutritious and appealing option for consumers. However, the study did not comprehensively address potential limitations. These may include the relatively narrow scope of sensory evaluation, as the panel size and demographic diversity were not specified, which could affect the generalizability of consumer acceptability results. Additionally, the study focused primarily on short-term sensory and nutritional characteristics without assessing the product's shelf life, microbial stability, or long-term consumer acceptance under real market conditions.

Andronoiu et al. (2022) explored the use of beetroot peel powder (BPP) as a functional ingredient in mayonnaise. The objective was to utilize agro-food by-products to improve the nutritional and sensory properties of mayonnaise. The process involved incorporating BPP at different concentrations (1.5%, 3%, 5%, and 7%) into mayonnaise formulations. The enriched mayonnaise was then analysed for its phytochemical content, antioxidant activity, viscosity, colour, and texture. The study found that BPP significantly increased the phenolic content and antioxidant activity, improved texture and viscosity, and enhanced

sensory attributes such as colour and taste, thereby validating the use of beetroot by-products in value-added food products.

The research by Ingle et al. (2017) focused on the nutritional evaluation of cookies enriched with beetroot powder. The objective was to create a fibre-rich, nutritious snack. The process involved substituting refined wheat flour with beetroot powder at various levels (5%, 10%, 15%, and 20%). The cookies were assessed for their physical properties, nutritional content, and sensory attributes. The findings revealed that incorporating beetroot powder improved the dietary fibre content and antioxidant properties of the cookies. Sensory evaluation indicated that compared to other samples, cookies with up to 10% beetroot powder were well-accepted in terms of taste, texture, and overall appeal.

Chaudhari and Nikam (2015) aimed to develop a beetroot jelly with enhanced nutritional and sensory properties. The objective was to utilize beetroot's natural colour and nutritional benefits in a jelly product. The process involved extracting beetroot juice and combining it with pectin, sugar, and citric acid. The mixture was heated to form a jelly, which was then evaluated for its texture, colour, flavour, and overall acceptability. The study concluded that beetroot jelly had a high acceptability score, with consumers appreciating its unique colour and flavour, making it a viable product for the market.

Mohamed et al. (2016) focused on fortifying pasta with beetroot to enhance its nutritional value. The objective was to create a functional food product with added health benefits. The process involved incorporating beetroot powder into pasta dough at different ratios (5%, 10%, and 15%). The fortified pasta was then analysed for its physical properties, nutritional content, and

sensory characteristics. The study found that beetroot fortification improved the pasta's fibre content and antioxidant activity. Sensory evaluation showed that pasta with up to 10% beetroot powder was well-received in terms of taste, colour, and texture.

Dhadage et al. (2015) investigated the development of multigrain snacks fortified with beetroot powder. The objective was to enhance the nutritional profile of snacks while maintaining consumer acceptability. The process involved mixing beetroot powder with various grains to create a dough, which was then shaped and baked into snacks. The final product was assessed for its nutritional content, including fibre and antioxidant levels, as well as sensory properties. The results indicated that beetroot fortification significantly improved the nutritional quality of the snacks without compromising their taste and texture.

Fernández-López et al. (2023) explored the use of beetroot juice as a natural colorant in plant-based meat analogues. The objective was to enhance the visual appeal and nutritional quality of meat substitutes. The process involved incorporating beetroot juice into the formulations of plant-based meat analogues and assessing the colour stability, betalain composition, and antioxidant activity. The study found that beetroot juice significantly improved the colour and antioxidant properties of the meat analogues, making them more appealing and nutritious for consumers.

Alsuhaibani (2013) aimed to evaluate the nutritional and sensory properties of biscuits fortified with red beetroots. The objective was to create a healthier snack option. The process involved adding beetroot powder to biscuit dough at various concentrations and then baking the biscuits. The fortified

biscuits were analysed for their nutritional content, including fibre and antioxidants, as well as their sensory attributes. The findings indicated that beetroot fortification enhanced the nutritional profile and provided a distinctive colour and flavour that were well-accepted by consumers.

Mridula et al. (2016) focused on developing nutritious pasta by combining groundnut meal with beetroot powder. The objective was to create a high-protein, high-fibre pasta with added health benefits. The process involved optimizing the proportions of groundnut meal and beetroot powder in the pasta dough. The resulting pasta was evaluated for its nutritional content, texture, and sensory properties. The study concluded that the optimized formulation provided a balanced nutritional profile with improved taste and texture, making it a suitable alternative to traditional pasta.

Lazăr et al. (2022) examined the formulation of beetroot-based mayonnaise using beetroot peel powder. The objective was to utilize beetroot by-products to create a healthier mayonnaise. The process involved incorporating beetroot peel powder into mayonnaise and evaluating its impact on the product's phytochemical composition, antioxidant activity, texture, and sensory properties. The results showed that beetroot peel powder enhanced the nutritional value and sensory attributes of mayonnaise, suggesting its potential as a natural ingredient in various food products.

Santos et al. (2023) explored the valorisation of soursop (*Annona muricata*) by-products to create various food products, including spreads. The objective was to reduce environmental waste and create economically valuable products from soursop by-products such as damaged fruits, seeds, and peels. The study detailed the chemical composition of these by-products, noting their

rich phytochemical content, including flavonoids and acetogenins. The process involved extracting these compounds and integrating them into new food products. This comprehensive valorisation approach not only aimed at waste reduction but also at producing nutritionally rich spreads and other consumables, highlighting the sustainability and economic benefits of using soursop by-products in the food industry (Santos et al., 2023).

Another significant work by Olagunju and Sandewa (2018) focused on the formulation of a functional soursop-based milkshake. The study aimed to develop a drink that leverages the high antioxidant content and unique flavour profile of soursop. The process involved blending soursop pulp with milk and honey, followed by evaluating the physicochemical properties, antioxidant activity, and sensory attributes of the resultant milkshake. The study found that the addition of milk significantly enhanced the flavonoid content and antioxidant properties of the drink, making it a highly acceptable functional beverage. This research highlighted the potential of soursop in creating health-oriented food products and provided insights into the sensory acceptance of such innovations (Olagunju & Sandewa, 2018).

Based on the findings above, there is a gap in research specifically focused on the development of beetroot and soursop spreads combined. While numerous studies have explored the incorporation of beetroot into various food products like cream cheese spreads, mayonnaise, cookies, jelly, pasta, and snacks, and some research has been done on soursop-based products, there is a lack of studies that combine these two ingredients in a spread format. This current study seeks to fill this gap by investigating the processes involved in developing a novel spread that incorporates both beetroot and soursop. By

combining these nutrient-rich ingredients, the study aims to create a unique spread that capitalizes on the health benefits, antioxidant properties, and distinctive flavours of both beetroot and soursop. This research could potentially lead to the development of a new functional food product that not only offers enhanced nutritional value but also provides an innovative flavour profile, thereby expanding the range of healthy spread options available to consumers.

Nutritional Composition of Beetroot and Soursop Jam

Okudu and Umahi (2017) investigated the nutritional composition of soursop (*Annona muricata L.*) jam, revealing its rich nutrient profile. The research aimed to determine the proximate composition, which includes moisture, crude protein, crude fat, ash, and carbohydrates. The soursop jam was found to have a moisture content of 42.77g/100g, crude protein of 1.17g/100g, crude fat of 0.19g/100g, ash content of 0.60g/100g, and carbohydrates of 55.27g/100g. This composition indicates that soursop jam is a low-fat product with moderate protein content and significant carbohydrate presence, making it a potentially valuable energy source. Additionally, the study highlighted the presence of essential minerals like calcium, potassium, and magnesium, which contribute to the jam's nutritional value (Okudu & Umahi, 2017).

Iombor, Olaitan, and Ede (2014) explored the effects of different drying methods on the nutritional composition of soursop flour, which can be analogous to soursop jam. The objective was to compare the proximate composition between freeze-dried and oven-dried soursop flour. The results showed that freeze-dried soursop retained more nutrients, with higher levels of moisture (12.40%), protein (8.10%), fat (0.82%), fibre (18.72%), and ash

(7.30%) compared to the oven-dried counterpart. These findings suggest that the drying method significantly affects the nutrient retention in soursop products, with freeze drying being more effective in preserving the nutritional quality

Agbo et al. (2022) examined the nutritional composition of soursop fruit pulp from different geographical locations to understand the impact of environmental factors on nutrient content. The research, conducted on mature fruits from various regions in Nigeria, assessed proximate, mineral, and vitamin compositions. Significant variability was observed, with certain accessions showing higher crude fat, fibre, protein, and carbohydrate contents. For instance, the Osokwa-Nvosi accession had the highest crude fat (8.05%) and fibre (3.96%), while the Obollo-Afor accession had the highest protein (2.87%) and moisture content. The study concluded that geographical location influences the nutritional composition of soursop, with specific accessions demonstrating superior nutritional profiles, which is crucial for selecting optimal cultivation sites for maximum nutrient yield (Agbo et al., 2022)

From the above, there is a clear gap in the existing research. While studies have separately examined the nutritional profiles of soursop jam and various beetroot-incorporated products, no research specifically investigates the nutritional composition of a combined beetroot and soursop jam or spread. This study seeks to fill this gap by analysing the nutritional composition of a novel beetroot and soursop jam. It aims to determine how the combination of these two nutrient-rich ingredients affects the overall nutritional profile, including proximate composition (moisture, protein, fat, ash, and carbohydrates), mineral content, and potential antioxidant properties. By doing so, this research will

provide valuable insights into the potential synergistic nutritional benefits of combining beetroot and soursop in a single product. This information could be crucial for developing new functional foods that leverage the unique nutritional attributes of both ingredients, potentially offering enhanced health benefits compared to jams or spreads made from either ingredient alone.

Consumer Acceptability of the Beetroot and Soursop Jam

A study by Dubey et al. (2023) investigated the incorporation of jaggery in beetroot jam to enhance its antioxidant properties and evaluate sensory attributes such as odour, colour, taste, and overall acceptance. The objective was to create a healthier alternative to traditional beetroot jam by partially replacing sugar with jaggery. Sensory evaluations using the Compromised Acceptance Threshold (CAT) method indicated that the partial replacement of sugar with jaggery was well-received by consumers. The study found significant improvements in the sensory attributes of the jam, particularly its colour and taste, leading to higher consumer acceptability scores (Dubey et al., 2022).

Another research by Irshad et al. (2020) explored the development and sensory evaluation of jam produced from pineapple and carrot blends. The primary objective was to improve the nutritional value and consumer acceptability of the jam by combining these two ingredients. The study involved a detailed proximate analysis to determine the moisture, ash, protein, fat, crude fibre, and carbohydrate content of the jam. Sensory evaluations indicated that the pineapple-carrot jam was highly acceptable to consumers, with favourable scores for flavour, texture, and overall acceptability. The incorporation of carrot enhanced the nutritional profile and contributed to a unique and pleasant taste, making the jam more appealing to consumers (Irshad et al., 2020).

A comprehensive evaluation by Parn et al. (2015) focused on beetroot-based products, including the development of beetroot jam, pickle, and powder. The study aimed to assess the overall acceptability of these products among consumers. Sensory evaluations revealed that beetroot jam had the highest scores in terms of texture, flavour, and overall acceptability compared to beetroot pickle and powder. The jam's colour and spreadability were particularly appreciated, leading to higher consumer preference. The study concluded that beetroot jam, with its appealing sensory attributes and enhanced nutritional profile, could be a popular choice among health-conscious consumers (Parn et al., 2015).

Despite the research on the development and sensory evaluation of various jams, there remains a notable gap in the literature regarding the consumer acceptability of jams specifically made from beetroot and soursop. This study seeks to fill this gap by evaluating the consumer acceptability of beetroot and soursop jam spread, focusing on sensory attributes such as taste, texture, and overall appeal, to determine if the combination can create a novel and highly acceptable product among health-conscious consumers. This research aims to provide insights into how these combinations can be optimized to meet consumer preferences, potentially leading to new market opportunities for innovative jam products.

The Life Span of Beetroot and Soursop Jam without any Changes in Quality Attributes

Ajibola et al. (2019) investigated the shelf life and quality retention of beetroot jam over a period of six months. The study employed various storage conditions to evaluate the jam's physicochemical properties, microbial stability,

and sensory attributes. The authors found that beetroot jam retained its quality attributes, such as colour, taste, and texture, effectively under refrigeration. However, ambient storage conditions led to a noticeable decline in sensory quality after three months. The microbial analysis indicated that proper sealing and pasteurization were crucial for preventing spoilage.

Mendes et al. (2020) examined the preservation of soursop jam using natural preservatives and packaging methods. The study assessed the impact of different natural preservatives, such as lemon juice and ascorbic acid, on the jam's shelf life. The authors reported that soursop jam with added lemon juice exhibited prolonged shelf life and maintained its quality attributes better than the control sample. Sensory evaluation revealed that the treated jam samples were acceptable to consumers even after six months of storage.

Likewise, Sandhya and Priya (2017) set out to create a few value-added storable products (beetroot jam, pickle, and biscuits) and evaluate how long they would last on the shelf. For three months, all of the storable goods were maintained at room temperature (29–30 °C). At each of the nine intervals, their sensory qualities were assessed using the Nine-point hedonic scale, and their microbiological composition was examined using the Pour Plate Technique. According to the results, pickles and biscuits made from beetroot can be stored for up to 75 days, while beetroot jam can be stored for up to 60 days. All of the storable items' microbial loads, however, were within the acceptable range for three months of storage, thus they can store up to 3 months and also safe for consumption.

Singh et al. (2018) focused on the stability and quality parameters of beetroot jam stored under various environmental conditions. The authors

utilized both chemical and sensory analysis to monitor changes over a six-month period. They discovered that beetroot jam stored at cooler temperatures retained its quality attributes significantly better than those stored at room temperature. The study concluded that temperature control is vital for maintaining the quality of beetroot jam over extended storage periods.

Dlamini et al. (2021) explored the use of different packaging materials on the shelf life of soursop jam. The study evaluated the impact of glass jars, plastic containers, and vacuum-sealed pouches on the quality attributes of the jam. The authors observed that vacuum-sealed pouches provided the best preservation of sensory and nutritional qualities over six months. Glass jars were also effective but slightly less so compared to vacuum-sealed pouches.

Rahman et al. (2022) studied the impact of different sweeteners on the shelf life and quality of beetroot jam. The researchers compared traditional sucrose with alternatives like stevia and honey. Their findings indicated that beetroot jam made with honey had a slightly longer shelf life and better retention of sensory qualities than those made with sucrose or stevia. The study also highlighted the importance of selecting appropriate sweeteners to enhance both the preservation and health benefits of the jam.

Despite research on the preservation and shelf life of beetroot and soursop jams, there remains a gap in the comparative analysis of the impact of different preservation methods on the long-term quality attributes of both types of jam under identical storage conditions. The existing studies by Ajibola et al. (2019), Mendes et al. (2020), Singh et al. (2018), Dlamini et al. (2021), and Rahman et al. (2022) predominantly focus on isolated factors such as refrigeration, natural preservatives, packaging materials, and sweeteners

independently. This study seeks to fill the gap by conducting a comprehensive comparative analysis that simultaneously evaluates the effects of these preservation techniques on both beetroot and soursop jams over an extended period. By integrating various preservation methods and analysing their combined impact on physicochemical properties, microbial stability, and sensory attributes, this research aims to provide a more holistic understanding of how to optimize the shelf life and maintain the quality of both beetroot and soursop jams.

Gaps and Lessons Learned from the Empirical Review

The empirical review demonstrates that beetroot and soursop have been successfully incorporated into various food products such as jams, jellies, cookies, pasta, mayonnaise, and beverages, with studies consistently reporting improvements in nutritional value, antioxidant properties, and consumer appeal. However, a clear gap exists in research that specifically investigates the formulation, nutritional composition, sensory acceptability, and shelf-life of a combined beetroot–soursop spread. Most existing studies focus on single-ingredient applications, either beetroot or soursop alone, or in combination with other unrelated ingredients such as dairy products, cereals, or tropical fruits like pineapple and carrot. Additionally, although shelf-life studies exist for beetroot-based and soursop-based products independently, there is little evidence of integrated investigations comparing preservation techniques for both ingredients within the same product under identical storage conditions. Lessons learned from previous studies highlight the importance of ingredient optimisation, incorporation of functional by-products, and the need to evaluate

both sensory attributes and physicochemical stability over time to ensure market-ready quality.

Several research gaps and conflicting findings emerge from the literature. First, there is no documented study that evaluates the combined nutritional and sensory outcomes of beetroot and soursop in a single spreadable product. While beetroot is consistently reported to enhance antioxidant activity and colour stability in diverse food matrices, the extent to which these benefits persist when combined with soursop—known for its delicate flavour and high vitamin content—remains unexplored. Second, shelf-life research has been fragmented, often focusing on single variables such as storage temperature, packaging material, or natural preservative use, without a holistic, comparative analysis of their combined effects. This fragmented approach leads to inconsistent recommendations on optimal preservation strategies. Furthermore, there is limited evidence on consumer perceptions of beetroot–soursop combinations, particularly in African or developing-country contexts, where cultural familiarity and affordability significantly influence acceptance.

CHAPTER THREE

RESEARCH METHODS

Introduction

The study approach is described in detail in this chapter. This part of the chapter consists of the research design, study area, study subject, and research design. It also covers data collection instrument, data collection procedure, analysis and interpretation of the collected data, and ethical considerations.

Research Design

The study employed an experimental research design, which is appropriate for food product development as it allows for controlled formulation, evaluation, and comparison of product variants under standardized conditions. This design facilitated the assessment of the nutritional composition, sensory acceptability, and shelf-life stability of the Beetroot-Soursop-Dates preserve.

Study Area

The study area is the location where participants would offer response to aid the study's progress. In this case the panellists used for the sensory evaluation of the BeetSop jam were sampled from the University of Cape Coast. The inclusion criteria required that participants be students or staff of the University of Cape Coast who were in good health, willing to participate voluntarily, and able to provide informed consent. The development of the product, proximate analyses was done at Teaching and Research Farm of the School of Agriculture, University of Cape Coast, and shelf-life determination of the developed product were all done at the Department of Laboratory

Technology, while the sensory evaluation was conducted at the Department of Vocational and Technical Education, also at the same university.

Population

The target population was made up of department of Vocational and Technical Education students because the students have in-depth knowledge about product development, and their sense of judgement on the developed BeetSop jam was trusted. The researcher also used the students in Vocational and Technical Education because they were close in proximity to the researcher.

Sampling Procedure

The researcher selected the respondents for the study using the purposive sample technique, which enabled the researcher to focus on those who use spreads and are not sensitive to the components used to create the new product. Purposive sampling, also known as judgment sampling, is a method where participants are specifically chosen based on their attributes, it is a nonrandom method that doesn't require a predetermined number of participants or underlying ideas (Bernard, 2017).

For the study, respondents were chosen from the Vocational and Technical Education students. A total of 80 students in all were chosen to test the new product on the University of Cape Coast campus. The chosen sample size was in accordance with the specifications for the hedonic method of sensory evaluation, which calls for between 75 and 150 participants in such research. According Shiby and Tabassum (2021) hedonic scale is also called affective or likeness tests, these tests normally involve as many as 75-150 untrained tasters (also called sensory panelists) with the goal to determine the expected consumer acceptability. The hedonic scale assumes that participants' preferences exist on

a continuum and that their responses can be categorized into like and dislike (Lawless & Heymann, 2013).

The purposive sampling approach was selected to ensure participants were available, willing to provide informed consent, and met the inclusion criteria of having no allergies to beetroot, soursop, or dates. This approach also allowed for efficient data collection within the study's resource limitations. However, the study recognizes that broader sampling strategies could produce findings more representative of the general consumer population.

Data Collection Instrument

A well-structured questionnaire was used to obtain data from the participants about the sensory evaluation of the varied jam spreads. The sensory evaluation questionnaire was adapted from Eusala and Pendon (2016) and Perumpuli et al. (2018). It assessed key attributes including colour, aroma, taste, texture, mouthfeel, and overall acceptability using a 5-point hedonic scale, consistent with widely applied sensory evaluation methods in food science research. Minor adjustments were made to ensure contextual relevance to the BeetSop preserve, while retaining the validated structure and content of the original instruments.

Material and Methods

Materials

Raw beetroot, soursop and dates were obtained from the Kotokraba market and were physically examined to ensure that they were free from foreign materials and meet the quality standards for the laboratory work. Standards protocols and procedures for making jam were employed to produce the novel preserve.

Sample Preparation

Preparation of BeetSop Jam

The raw beetroot, soursop and dates were pre-cleaned by washing them with clean water at least three times and dried with clean napkin. The date seeds were then separated from the dates and sun dried, after which the date was blended into powder. The beetroot was peeled and cut into small, uniform pieces to ensure even cooking and consistent texture in the final product while the soursop seeds were taken out from the pulp and two blended together.

Different ratios of the blended beetroot and soursop were formulated and simmered for 20 to 30 minutes at 105°C and stirred while simmering to prevent the jam from sticking to the cooking pan. The simmering process continued till the water was reduced by 3/4. The date powder and lemon juice were added 2 minutes into the simmering of the mixture. Lemon was added for pectin. For every 550g of the sample, 350g of date was added. Pectin act as natural gelling agent, which helps the jam set properly

Preparation of black plum Jam

Fully ripened black-plum (*V. doniana*) fruits were bought from Kotokraba Market, Cape Coast. Other raw materials which included sugar, lime and bottles for packaging were purchased at Koforidua market in Eastern Region. The black-plum fruits washed under running water, weighed and blended in a blender. The seeds and skins were separated from the pulp with the addition of water to facilitate the separation using a 2mm round perforated holes coarse sieve.

Black-plum jam was prepared using the open kettle method as described by DeGregorio (2000). The extracted pulp (550g) was poured into a pot and

brought to boil to concentrate at atmospheric pressure and temperature 105°C. 350g of sugar was added to the boiling pulp while stirring vigorously until it achieved desired consistency. Lime was added to adjust the pH to 3.2 and further heated to remove excess water from the lime. The jam was filled into jars, which had been washed properly with soap and water and sterilized by boiling (jars and lids separated) in water to 100°C for 10 min, while hot. A quarter (1/4inch) headspace was left at the top of the bottles, the headspace allows room for this expansion without causing the jar to overflow or the lid to pop off. Samples of the preserves were stored at ambient and refrigeration temperatures. Figure 4 outlines the sequential steps that were followed to produce the novel BeetSop preserve. The processes resulted in the development of four samples:

Sample “A” (BPJ) which was made out 100% black-plum fruit

Sample “B” (BAS) which was made out 50% beetroot and 50% soursop.

Sample “C” (SWB) which was made out of 75% soursop with 25% beetroot.

Sample “D” (BWS) which was made out of 75% beetroot with 25% soursop.

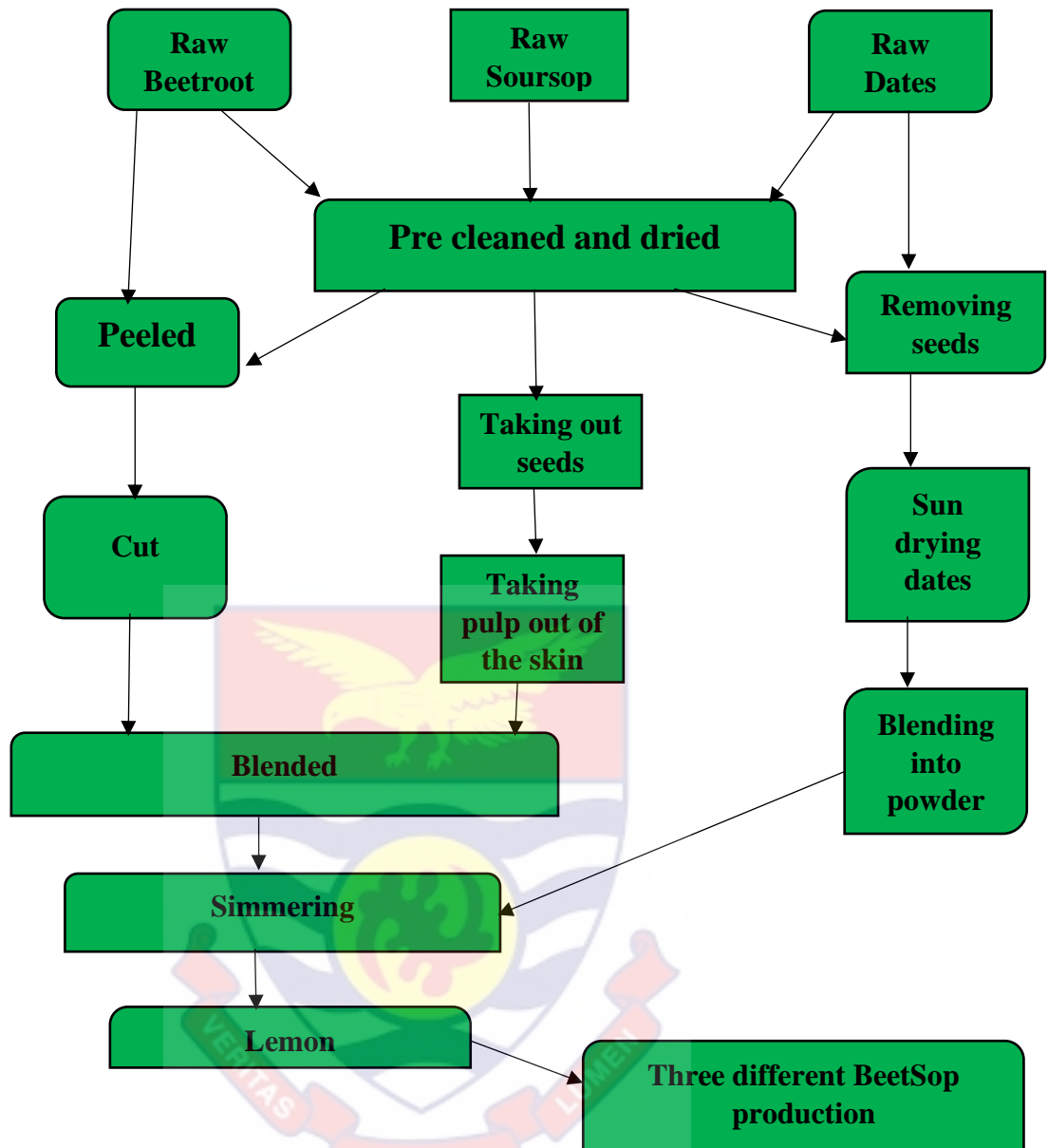


Figure 4: Flowchart for the production of BeetSop jam

Source: Opoku (2024)

Data Collection Procedures

There were three phases to data gathering. The first and second phases comprised the laboratory work. The first phase consisted of the proximate analysis of developed samples to ascertain the nutritional composition of samples, while the second phase involved the microbial analysis of samples to determine if the procedures compromised the and the keeping quality and thus, the safety of the developed product. The last phase comprised the sensory

evaluation of the developed BeetSop preserve. The samples were served with a quarter slice of bread. The samples were served to the 80 selected participants who evaluate the product to determine which of the ratios they perceived as the best product.

Nutrition composition of samples determined were proximate composition in addition to protein, calcium, magnesium, zinc, potassium, sodium, iron and copper. The shelf-life analysis was subject to a laboratory test where four microbial profiles (*Aerobic Plate Count*, *Total Coliform*, *Salmonella spp*, and *Rhizopus stolonifer*) were examined. Sensory assessment of the developed preserve was conducted using a self-developed consumer acceptability survey questionnaire to determine the sample they perceived as the best product.

Nutrition analyses were conducted the Teaching and Research Laboratory, School of Agriculture, microbial determinations at Department of Laboratory Technology and sensory analysis at the Department of Vocational and Technical food laboratory, all at the university of Cape Coast. The samples were sensorily evaluated by 80 panel who are not allergic to any of the ingredients used and are consumers of jam.

Methods

Nutritional Analysis

Nutritional analysis comprises of proximate and mineral analysis. The nutritional content of the produced BeetSop jam samples was examined. Parameters included protein, calcium, carbohydrate, lipids, crude fibre, magnesium, potassium, zinc, salt, iron, copper, and ash. Records and comparisons were made on the nutritional composition of the different jam

samples. Hydrogen peroxide, sulphate (CuSO_4), potassium sulphate (K_2SO_4), copper, sodium hydroxide solution, sulphuric acid, and petroleum spirit was employed in the laboratory for the proximate analysis. The methods described by AOAC (2008) were adopted.

Proximate Analysis

Crude Fiber Determination

Reagents

Sodium hydroxide, 1.25%

1.25%. Dissolve 12.5g NaOH in 700ml distilled water in a 1000ml volumetric flask and dilute to volume.

Sulphuric Acid, 1.25%

Add 12.5g conc. Sulphuric acid to a volumetric flask containing 400ml distilled water and dilute to volume.

Procedure

About 1g of the sample was weighed and placed in a boiling flask, 100ml of the 1.25% sulphuric acid was added and boiled for 30mins. After the boiling, filtration was done in a numbered sintered glass crucible. The residue was transferred back into the boiling flask and 100ml of the 1.25% NaOH solution was added and boiled for 30mins. Filtration continued after the boiling and the residue washed with boiling water and methanol. The crucible was dried in an oven at 105 degrees overnight and weighed. The crucible was placed in a furnace at 500 degrees for about 4 hours. The crucible was slowly cooled to room temp in a desiccator and weighed.

Calculation

$$\% \text{ Crude fibre} = \text{weight loss thro ashing} / \text{sample weight} \times 100$$

Carbohydrate Determination

A 50 ml conical flask was filled with 500 ml of each spread sample, 30 ml of distilled water was added, and a bubble was placed in the neck to gently simmer on a hot plate for two hours. Periodically, this was increased to 30ml, allowed to cool slightly, and then a 50ml volumetric flask was used to filter the mixture through No. 44 Whatman paper before it was diluted to volume. The extract was ready right before colour development. The extract was prepared just before colour development. Using the same process, a blank was prepared. The solution's colour was developed by pipetting 2 ml of each standard into a set of boiling tubes, together with 2 ml of extracts and a water blank. Both standards and samples were handled equally. The tubes were quickly mixed with 10ml of anthrone solution before being submerged in flowing water. The tubes were cooked for 10 minutes in a beaker of boiling water in a dimly lit fume cupboard. The tubes were then submerged in ice water and given time to cool, ideally in complete darkness. At 625nm, the optical density was measured using a red filter and water as a standard. The standard was used to create a calibration graph, which was used to determine the amount of glucose in the sample aliquot. The blank determination was handled similarly, and any necessary subtractions was made.

$$\% \text{ Soluble Carbohydrate (\%)} = \frac{C(\text{mg}) \times \text{extract volume (ml)}}{10 \times \text{aliquot (ml)} \times \text{sample weight (g)}}$$

Where C= carbohydrate concentration from the calibration graph

Sulphuric Acid-Hydrogen Peroxide Digestion

The digestion combination consists of 420mL sulfuric acid, 14g lithium sulphate, 0.42g powdered selenium, and 350mL hydrogen peroxide. According to Allen et al. (1974), the digestion process involves weighing between 0.1000g and 0.2000g of the pulverized sample that had been oven-dried. Then, 4.4mL of the mixed digestion reagent is added, and the samples are digested for two hours at 360°C. Analyses of the digestion mixture without a sample, or blank digestions, were conducted in the same manner. Following digestion, the digests were weighed out and volumetrically placed into 100 mL volumetric flasks.

Colorimetric Determination of P using the Ascorbic Acid Method

The procedure requires the preparation of colour forming reagent and P standard solutions. The colour forming reagent was made up of reagents A and B. Reagent A was made up of 12g ammonium molybdate in 20ml distilled water 0.2908g of potassium antimony tartrate in 100mL distilled water and 1L of 2.5M H₂SO₄. The three solutions were mixed in a 2L volumetric flask and made up to volume with distilled water.

Reagent B was prepared by dissolving 1.56g of ascorbic acid to every 200mL of reagent A. A stock solution of 100µgP/mL solution was prepared from which 5µgP/mL solution a set of working standards of P with concentrations 0, 0.1, 0.2, 0.4, 0.6, 0.8 and 1.0µgP/mL in 25mL volumetric flasks. 2mL aliquot of the digested samples were pipette into 25mL volumetric flasks. 2mL aliquot of the blank digest were pipette into each of the working standards to give the samples and the standards the same background solution.

Ten millilitres (10ml) of distilled water were added to the standards as well as the samples after which 4 mL of reagent B was added and their volumes

made up to 25mL with distilled water and mixed thoroughly. The flasks were allowed to stand for 15minutes for colour development after which the absorbances of the standards and samples were determined using a spectrophotometer at a wavelength of 882.nm. A calibration curve was plotted using their concentrations and absorbances. The concentrations of the sample solutions were extrapolated from the standard curve.

Calculation

If $C = \mu\text{gP/mL}$ obtained from the graph,

then $\mu\text{gP/g (sample)} = C \times \text{dilution factor} / \text{weight of sample}$

(IITA, 1985)

Mineral Analysis

Determination of Potassium and Sodium

Using a flame photometer, the amounts of potassium and sodium in the digested samples were measured. The following K and Na working standards were prepared in the determination: 0, 2, 4, 6, 8, and 10 $\mu\text{g/mL}$. Each of the working standards and sample solutions was inhaled into the flame photometer separately, and the emissions, or readings, were noted. Using the working standards' concentrations and emissions, a calibration curve was created. By utilizing their emissions, the concentrations of the sample solutions were calculated based on the standard curve.

Calculation

$\mu\text{gNa/g} = C \times \text{solution volume} / \text{sample weight}$

Stewart et. al (1974)

Determination of Calcium and Magnesium by Edta Titration

Using ethylene diamine tetra acetic acid (EDTA), the cations are chelated as part of the procedure. The process comprised measuring magnesium and calcium together as well as calcium alone and magnesium identified by difference.

An aliquot of 10 mL of the sample solution was placed in a 250 mL conical flask, and the solution was diluted to 150 mL with distilled water, 15 mL of buffer solution, and 1 mL of each of potassium cyanide, hydroxylamine hydrochloride, potassium ferro-cyanide, and triethanolamine (TEA). This allowed for the determination of calcium and magnesium together. Eriochromes Black T (EBT) was added in five drops, and the mixture was titrated against 0.005M EDTA. In order to measure the calcium content, 10 mL of the sample solution were pipetted into a 250 mL conical flask and diluted with 150 mL of distilled water. Potassium cyanide and potassium ferrocyanide with hydroxylamine hydrochloride, each in 1 millilitre and TEA five drops of calcon indicator were added and the solution was titrated with 0.005M EDTA.

Calculations

$$\% \text{ Ca} = 0.005 \times 40.08 \times T / \text{sample weight}$$

$$\% \text{ Mg} = 0.005 \times 24.31 \times T / \text{sample weight}$$

Where T = titre value

Determination of Iron, Copper and Zinc using atomic Absorption Spectrophotometer

Fe, Cu, and Zn standard solutions in concentrations of 1, 2, and 5 $\mu\text{g}/\text{mL}$ were made. Plotting the corresponding calibration curves on the atomic absorption spectrophotometer (AAS) followed the aspiration of the standard

solutions into the AAs. The concentrations of the sample solutions were given as they were aspirated.

Calculations

$$\text{Fe } (\mu\text{g/g}) = C \times \text{solution volume} / \text{weight of sample}$$

$$\text{Cu } (\mu\text{g/g}) = C \times \text{solution volume} / \text{weight of sample}$$

$$\text{Zn } (\mu\text{g/g}) = C \times \text{solution volume} / \text{weight of sample}$$

Microbial Analysis

Vertical Steam Autoclave, Bunsen burner, Buffered Peptone water (Microgen), [(Eosin Methylene Blue (Levine), Plate Count Agar, *Salmonella/Shigella* agar, Potato Dextrose agar, Oxoid] 70% Ethanol, Guardian Class II Biological Safety Cabinets MSC T800 (Monmouth UK), SIM Agar.

Shelf life Determination

The samples were subjected to analysis in order to detect *Salmonella* sp., total coliforms, *Rhizopus stolonifer*. The standard plate count method was utilized for this purpose (Chouhan, 2015). In accordance with ISO standards (ISO 4833, 2013), the samples were subjected to a pour plate method/technique analysis for the following purposes: total coliform count, *Rhizopus stolonifer*, colony-forming units (CFU) per millilitre, aerobic plate count, and *Salmonella* spp count.

The manufacturer's instructions were followed to prepare culture media made up of Plate Count Agar (Oxoid), Eosin Methylene Blue Agar (Oxoid), Buffered Peptone Water (Microgen), *Salmonella/Shigella* agar (Oxoid), and Potato Dextrose agar (Oxoid). 180 ml of buffered peptone water (Oxoid) was created in triplicate for each sample using buffered peptone water as the

recovery diluent. All prepared media and petri dishes were autoclaved at 121°C, 15 pressure for 15 minutes to ensure sterilization.

After being sufficiently homogenized and stored at room temperature, 20g of the test sample were aseptically weighed into the recovery diluent (buffered peptone water), and the mixture was incubated for 30 minutes at 37°C in a water bath. In sterile buffered peptone water, the test sample was serially diluted to a 10⁻³ concentration.

Triplicate dilutions of 1 ml of 10⁻² sample were inoculated on Plate Count agar for the Aerobic Plate Count. The three-fold dilutions were cultured for 48 hours at 35±2°C in order to measure the aerobic plate count (CFU/ml) for every sample. Triplicate dilutions of 1 ml of 10⁻¹ sample were plated on Eosin Methylene Agar for the Total Coliform count. The samples were cultured for 48 hours at 35±2°C in triple dilutions to determine the total coliform count (CFU/ml).

Salmonella/Shigella agar was plated with triplicate dilutions of 1 ml of 10⁻¹ sample in order to count Salmonella sp. For 48 hours, each set of three dilutions was incubated at 35±2°C to determine the Salmonella sp. count (CFU/ml) for each sample. On Potato Dextrose agar treated with ampicillin, triplicate dilutions of 1 ml of 10⁻¹ sample were plated for Rhizopus stolonifer. For seven days, each triplicate dilution- was incubated at room temperature in order to measure the amount of yeast and mould (measured in CFU/ml) in the sample.

Sensory Evaluation

The three freshly created BeetSop jam were tested for acceptability and compared with the control to ascertain whether there was statistically significant

difference in acceptability, to provide the sensory data. This exercise was conducted in the food laboratory of the Department of Vocational and Technical Education, which is equipped with a controlled environment suitable for sensory evaluation. The laboratory provided adequate lighting, ventilation, and temperature control, with minimal noise and odour interference to prevent bias in panellists' perceptions. A sample of 80 students were sampled to constitute the sensory panel for the sensory evaluation. Each panel was provided a comfortable seat for the exercise. On their respective tables, the labelled samples were presented to them based on the order they follow in the questionnaire. Each panel member was given three disposable cups and a bottle of water. The water served as a means for them to rinse their mouths prior to each assessment of the various BeetSop varieties. Food qualities evaluated were flavour, texture, colour, and general acceptability on a five-point hedonic scale as shown in Figure 4.

Twenty respondents per batch were invited to conduct the sensory test. Prior to the testing, panel members received instructions from the researcher on the food features that were to be evaluated and how to fill out the questionnaire. They were then permitted to try the samples and respond to the questionnaire.

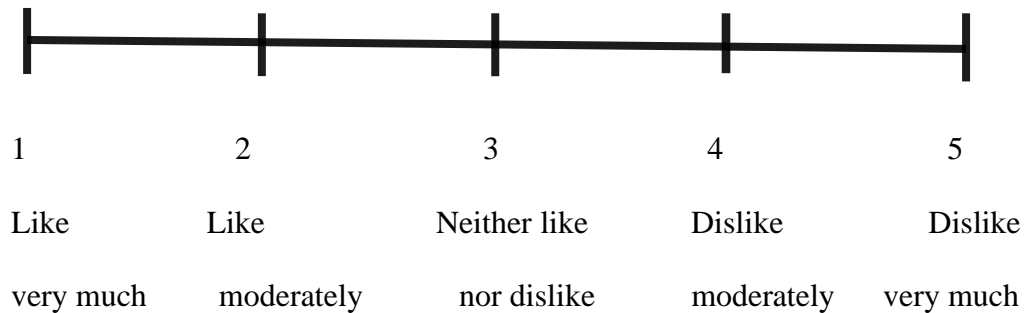


Figure 5: *Five-point hedonic scale*

Source: Dimple and Rohanie (2014)

Ethical Clearance and Inclusion Criteria

Ethical clearance for the study was obtained from the University of Cape Coast Institutional Review Board (IRB), with the approval ID UCCIRB/CES/2023/95. All participants provided informed consent prior to participation. Consent procedures included clear explanations of the study's purpose, evaluation methods, and assurance of voluntary withdrawal at any stage. Food safety standards were maintained during product development, including adherence to good manufacturing practices, proper sanitation, and safe handling procedures.

Data Analysis

Findings from the proximate analysis, microbial analysis and sensory evaluation was analysed using Microsoft Excel where the mean and standard deviation were generated to determine the significant level at 95% confidence level ($p < 0.05$). The panellists' overall acceptance of the products was used to choose the products with a mean score of 1 to 2 designating acceptance and 3-5 designating rejection.

Table 1: Research Objective-analysis

Research Objective	Type of analysis	Analytical tool
1.	Descriptive	Process description, qualitative observation, photographic documentation
2.	Descriptive & Inferential	Means, standard deviations, ANOVA for comparing proximate and mineral composition across formulations
3.	Descriptive & Inferential	Means, standard deviations, ANOVA, Tukey's HSD test for post-hoc comparisons of sensory scores
4.	Descriptive & Inferential	Means, standard deviations, repeated measures ANOVA for microbial counts and sensory scores over storage time

Data Management

The questionnaire was stored in an envelope during data collection and sealed until the researcher was ready to enter the information into SPSS. In order to prevent data duplication, each completed questionnaire will be marked as "entered" during the data entry process. The completed questionnaires were wrapped in an envelope, labelled with the completion date, and stored in a cabinet for a week after all entries have been made.

The researcher manually saved data every ten minutes to prevent data loss by mistake. At the end of the day, the data was secured with a password at the end of each day and backed up on both an external drive and the One Drive app.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

This chapter presents the results of the analyses of data and discussions of the findings on BeetSop jam. The purpose of the study was to produce innovative and nutrient rich spread from beetroot and soursop (jam) using date powder as a healthy sweetener. The first part of the analysis was based on the demographic characteristics of the adolescents involved in the study. This included gender and age. The second part of the analysis was based on research questions outlined in the study.

Research Question One: How feasible is the production of jam with beetroot and soursop (BeetSop jam)?

Research question one sought to determine the possibility of developing a jam preserve using beetroot and soursop with dates as a sweetener to determine the acceptability by consumers, sensory attributes with three days of storage, as well as to standardize the proportion and shelf life of the mixed fruit jam. As described in Chapter Three, raw beetroot, soursop, and dates were procured from the Kotokraba market.

The fruits were inspected rigorously to ensure they were free from foreign materials and met laboratory quality standards. The beetroot, soursop, and dates were thoroughly washed and dried, then the seeds were extracted from the dates, sun-dried, and blended into a powder, while the beetroot was peeled and cut into small pieces. The cut beetroot and soursop pulp were blended to form a homogeneous mixture.

The BeetSop jam samples were boiled at 220°F (104°C) to achieve desired consistency, gel formation, and preserve beetroot and soursop flavours and nutrients as recommended by Shashirekha et al (2015). The beetroot and soursop mixture were simmered for 20-30 minutes, stirring constantly to prevent sticking. The water content was reduced by three-quarters, and then date powder was added two minutes into the simmering process. Lemon juice provided pectin for the gel-like consistency, and 350g of date powder was added to each 550g sample. The prepared BeetSop jams were cooled and packaged into pasteurized containers. These containers were then stored in a cool, dry place.

Four samples of BeetSop jam were produced with varying proportions of beetroot and soursop:

Sample “A” (BPJ) which was made out 100% black-plum fruit

Sample “B” (BAS) which was made from 50% beetroot and 50% soursop.

Sample “C” (SWB) which was made from 75% soursop with 25% beetroot.

Sample “D” (BWS) which was made from 75% beetroot with 25% soursop.

Some studies on beetroot, noted that it is a rich source of antioxidants, vitamins, and minerals, has numerous health-promoting, anti-inflammatory, and anti-cancer properties (Clifford et al., 2015; Georgiev et al., 2010). Likewise, soursop, a traditional medicine with antimicrobial and antioxidant properties, is used for treating various ailments due to its alkaloids, steroids, and flavonoids (Coria-Télez et al., 2018; Leatemia & Isman, 2004). Research indicates that blending different fruits can result in a more balanced nutrient composition and improved taste (Jeffery, 2005; Shashirekha et al., 2015).

BeetSop jam was made using approved protocols by meticulously cleaning, blending, and simmering processes, with date powder and lemon juice added for sweetness and pectin. Combining multiple fruits enhances jam production, making BeetSop jam a valuable functional food addition. Based on this, it can be deduced that the combination of beetroot and soursop to form BeetSop jam leverages the unique health benefits of both fruits, creating a product that is not only nutritious and feasible but also appealing to consumers.

Research Question Two: What is the nutritional composition of the BeetSop Jam?

Nutritional Composition of BeetSop Jam

Research question two sought to determine the nutritional composition of the various samples of the BeetSop preserve. Four samples namely *BPJ* (control produced from black plum fruit), *BAS*, *SWB*, and *BWS* were produced from different proportions of beetroot and soursop. The results of the proximate analysis of the major and minor nutritional composition of the samples of beetroot and soursop preserve and black plum jam are presented in Table 2 and 3. The presented tables provide a comprehensive overview of the findings pertaining to seven (7) chemical constituents identified within the BeetSop jam and black plum jam. The examination involved a meticulous analysis, whereby the data obtained from the laboratory experiment was processed utilizing the Statistical Package for the Social Sciences (SPSS) software.

Dry matter

Dry matter refers to material remaining after removal of water present in the feed ingredient (Coleman, Berry, Pierce, Brennan, & Horan, 2010). Table 2 shows that the dry matter percentage in the samples ranged from 26.70% to

29.37%, with BWS having the highest dry matter percentage ($29.37 \pm .097$), followed by BPJ (control) ($29.36 \pm .037$), followed by SWB ($27.37 \pm .142$). BAS had the least dry matter percentage ($26.70 \pm .284$). Dry matter in BeetSop preserves enhances thickness, spreadability, mouth felt, shelf life, flavour intensity and inhibits water activity and microbial growth (Eke-Ejiofor, Allen, & Ekeolisa, 2019). BWS has the highest dry matter percentage ($29.37 \pm .097$), resulting in a thicker texture, longer shelf life, and intense flavour and nutrient compared to the control BPJ, SWB and BAS.

Moisture content

According to Mouritsen & Styrbæk (2017), the moisture level in your food significantly influences how it is processed, blended, and dehydrated, along with its final texture, appearance, and mouthfeel. The moisture content ranged from 70.62% to 73.30%, with BAS having the highest moisture ($73.30 \pm .099$), followed by SWB ($72.63 \pm .143$), then BWS ($70.63 \pm .198$) and BPJ (control) having the least ($70.62 \pm .037$). The combination of dry matter and moisture content resulted in a content level of approximately 100% for all samples. Though, high moisture content can lead to softer jam, it induces microbial growth, and dilutes concentration of nutrients (Alagöz, Türkyılmaz, Tağı, & Özkan, 2015). Too much moisture can result in a product that is more liquid than expected and can lead to clumping in dry mixtures, both of which are unappealing to your customers (Mouritsen, & Styrbæk, 2017). BAS has the highest moisture content ($73.30 \pm .198$ %), indicating a softer texture yet shorter shelf life and a reduced nutritional value per serving compared to BPJ (70.62%).

Ash content

The term "ash" describes the inorganic residue that remains in a food sample either ignition or complete oxidation of organic matter in a food sample, ash content is a crucial quality factor for certain food ingredients and is determined as part of proximate analysis for nutritional evaluation (Vassilev et al., 2017). Furthermore, the results revealed that Ash content ranged from 2.76% to 5.46 %, with BPJ (control) having the highest percentage ($5.46 \pm .002$), followed by BWS ($3.38 \pm .175$), then SWB ($3.11 \pm .017$) and BAS having lowest percentages of Ash Content ($2.76 \pm .017$). BeetSop jam, BWS recorded the highest ash and fat/oil content, which is crucial for bone health, enzyme function, body fluid balance, cell growth and source of energy when consumed (Afzaal et al., 2022; Clifford, Howatson, West, & Stevenson, 2015).

Protein content

A study conducted by Jennifer et.al, (2023) on varied proportions of soursop-beetroot beverage indicated a protein content that ranged from 0.97 to 1.94%. Protein content in the present study ranged from 4.23% to 7.63%, with BAS having the most protein of the three samples. The sample with the lowest protein content was BPJ (control) ($4.23 \pm .003$) whilst the sample with the highest protein content BAS ($7.63 \pm .074$), followed by BWS ($7.31 \pm .026$), and SWB ($7.30 \pm .028$). BAS has the highest protein concentration, making it an ideal choice for protein intake for individuals looking to build muscle or recover from intense physical activity (Areta et al., 2013).

Fat/Oil content

Eating too much saturated fats in your diet can raise "bad" LDL cholesterol in your blood, which can increase the risk of heart disease and stroke

(Upadhyay, 2023). The results also showed that the Fat/Oil content ranged from .089% to 3.81%. The sample with the highest fat/oil content was BPJ (control) ($3.81 \pm .003$), followed by BWS ($.126 \pm .003$), then BAS ($.099 \pm .001$) and the sample with the lowest fat/oil content was SWB ($0.89 \pm .002$). Oils and fats supply calories and essential fats and help your body absorb fat-soluble vitamins such as A, D, E and K (Dwivedi, Issar, & Tiwari, 2023).

Fibre content

The percentage of fibre found during the laboratory analysis indicated values which ranged from 1.25% to 7.10%. For the first time in the analysis, SWB ($7.10 \pm .025$) had the highest amount of content in terms of Fibre content. This was followed by BWS ($6.20 \pm .027$) then BAS ($6.05 \pm .054$) and the sample with least fibre content was the control BPJ ($1.25 \pm .007$). compared to the control BPJ, the other three samples made up of different proportions of beetroot and soursop had adequate fibre content. SWB, with its high fibre content, is essential for blood sugar regulation, digestive health, and satiety (Wu et al., 2023).

Carbohydrate content

Lastly, CHO content among the three samples ranged from 66.40% to 83.45%. According to the analysis, the content with the highest CHO content was BAS ($83.45 \pm .074$), followed by BWS ($83.00 \pm .177$) and SWB ($82.40 \pm .058$) while the least carbohydrate content was the control BPJ ($66.40 \pm .071$). BPJ recorded the highest carbohydrate content, making it an ideal energy source for those with high energy needs. Carbohydrates are your body's main source of energy: They help fuel your brain, kidneys, heart muscles, and central nervous system (Lema-Pérez, 2021).

It can be deduced from the analysis in Table 3 that overall, the sample with the most quantity of chemical constituent was BWS having second highest values six chemical constituents (moisture, ash, protein, fat/oil, fibre and carbohydrate) and BAS with having highest values three chemical constituents. BAS also scored highest values in *Moisture*, *Protein*, and *CHO*. The results of Table 3 also disclosed that there is a statistically significant difference between and within groups of the samples at a significance level of 0.05 alpha levels.

The nutritional composition of BeetSop preserves is varied, with differences in dry matter and moisture content affecting texture, shelf life, and flavour intensity. The presence of essential nutrients like protein, fat, fibre, and carbohydrates enhances the overall nutritional value of the preserve. Consumers can choose the preserve that best meets their nutritional needs and preferences based on these attributes.

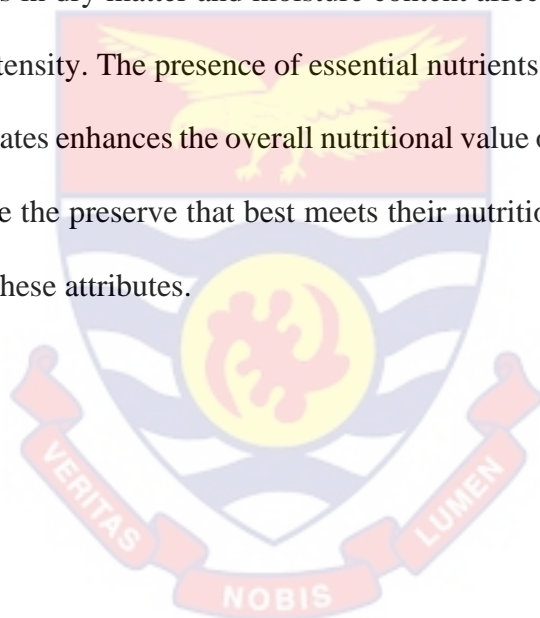


Table 2: Major Chemical Constituent of the Three of BeetSop Jam Sample

SAMPLE	Dry Matter %	Moisture %	Ash %	Protein %	Fat/oil %	Fibre %	CHO %
BPJ	29.36 ± .037	70.62 ± .037	5.46 ± .002	4.23 ± .003	3.81 ± .003	1.25 ± .007	66.40 ± .071
BAS	26.70 ± .284	73.30 ± .099	2.76 ± .053	7.63 ± .074	.099 ± .001	6.05 ± .054	83.45 ± .074
SWB	27.37 ± .142	72.63 ± .143	3.11 ± .017	7.30 ± .028	.089 ± .002	7.10 ± .025	82.40 ± .056
BWS	29.37 ± .097	70.63 ± .198	3.38 ± .175	7.31 ± .026	.126 ± .003	6.20 ± .027	83.00 ± .177

Source: Opoku (2024)

Sample: (BPJ= Black plum, BAS = Beetroot and Soursop, SWB = Soursop with Beetroot, & BWS = Beetroot with Soursop).

Values are averages of triplicate determinations

Data is represented as mean ± standard deviation

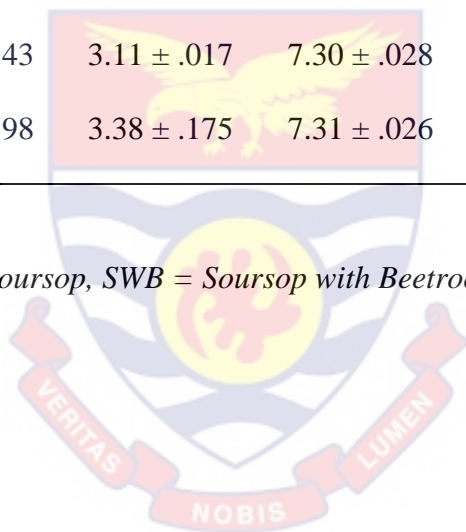


Table 3: ANOVA of Major Chemical Constituent of the Three of BeetSop Jam Sample

		Sum of Squares	Df	Mean Square	F	Sig
Dry Matter %	Between Groups	11.56	2	5.78	157.02	.000
	Within Groups	.22	6	.04		
Moisture %	Between Groups	13.25	2	6.13	173.18	.000
	Within Groups	.34	6	.12		
Ash %	Between Groups	.57	2	.29	25.28	.001
	Within Groups	.07	6	.01		
Protein %	Between Groups	.23	2	.114	49.00	.000
	Within Groups	.02	6	.00		
Oil/ Fat %	Between Groups	.002	2	.001	297.34	.000
	Within Groups	.00	6	.00		
Fibre %	Between Groups	1.91	2	.96	671.26	.000
	Within Groups	.01	6	.00		
CHO %	Between Groups	1.64	2	.82	61.22	.000
	Within Groups	.08	6	.01		

Source: Opoku (2024)

Significant $p < 0.05$.

Furthermore, the laboratory analysis of the four samples of BeetSop preserve and black plum jam revealed that the samples contain eight (8) chemical elements namely *Phosphorus, Potassium, Sodium, Zinc, Copper, Iron, Calcium, and Magnesium*. The results of the analysis of the chemical elements are presented in Table 4 and 5.

Phosphorus

Phosphorus content in the four samples of beetSop preserve and black plum jam range between 1915.08 ug/g to 2031.17 ug/g and SWB is the preserve with the highest content of phosphorus (2031.71 ± 21.97) followed by BWS (2020.19 ± 6.04) then BPJ (2010.38 ± 10.08). BAS recorded the least amount of phosphorus (1915.08 ± 08).

Potassium

In terms of Potassium, the results indicated content ranged between 5170.16 ug/g and 10132.76 ug/g. Overall, sample which recorded the highest Potassium content was SWB (10132.76 ± 272.37) followed by BAS (9293.19 ± 19), then BWS (9237.59 ± 124.99). The results showed that the difference between BAS and BWS in terms of potassium content was 57.6 ug/g meaning, the content of potassium these samples is almost the same. The control BPJ (5170.16 ± 2.64) had the least potassium content.

Sodium

The Sodium values ranged from 1040.14 ug/g to 2142.49 ug/g. The sample with the least content of sodium was BPJ (control) (1040.14 ± 39.26), followed by SWB (1541.23 ± 49.69) then BAS (2114.22 ± 51.25). The difference of sodium content between BWS (2142.49 ± 32) which has the highest content, and BAS is 28.27 ug/g. BWS also has the highest sodium

concentration (2142.29 $\mu\text{g/g}$), indicating its potency for fluid balance and nerve function. However, excessive consumption of sodium can cause hypertension (Kim, 2016).

Copper

The laboratory analysis also found that copper content in the jam spread samples ranged between 112.22 $\mu\text{g/g}$ and 270.37 $\mu\text{g/g}$. BPJ (control) ($270.37 \pm .45$) recorded the highest copper content followed by BAS (207.72 ± 2.58), then SWB (156.01 ± 1.97), while the sample with the least copper content was BWS ($112.22 \pm .31$). Copper is essential for the formation of red blood cells and connective tissues, the production of neurotransmitters, which are essential for proper brain function.

Zinc

Zinc content detected from the laboratory analysis showed that values ranged between 124.65 $\mu\text{g/g}$ and 276.46 $\mu\text{g/g}$. Among the four samples, SWB (276.46 ± 5.15) recorded the highest amount of Zinc in the preserve. BAS (257.73 ± 3.49) recorded the second highest followed by SWB (242.91 ± 1.07). The difference between BAS and BWS in terms of Zinc content was 14.82 $\mu\text{g/g}$ while the difference between BAS and SWB was 18.73 $\mu\text{g/g}$ indicating that Zinc content found in the samples of jam spread is almost the same level. BPJ (124.65 ± 2.66) the control recorded the least amount of zinc.

Iron

The laboratory analysis also disclosed that Iron content in the samples had values stretching between 3288.59 $\mu\text{g/g}$ and 5208.24 with BPJ the control (5208.24 ± 24) recording the highest content of Iron, followed by SWB

(3602.57 ± 109.21), then BWS (3357.19 ± 50.72). BAS (3288.59 ± 73.84) recorded the least value in iron.

Calcium

The laboratory analysis expressed Calcium in terms of percentages. The results showed that Calcium content in the preserves ranged between 1.25% and 1.49%. Among the samples, BAS ($1.49 \pm .035$) recorded the highest Calcium level, followed by the control BPJ ($1.40 \pm .036$), then SWB ($1.31 \pm .017$) and the sample with the least content of Iron was BWS ($1.25 \pm .059$). Calcium is crucial for bone health, muscle function, nerve transmission, and blood clotting.

Magnesium

Magnesium content in the samples ranged from .121% to .270%. BPJ (control) ($.270 \pm .045$) recorded the highest amount of magnesium, SWB ($.139 \pm .005$) recorded the second highest content in magnesium then BAS, ($.127 \pm .035$) while the samples with the least content was BWS ($.121 \pm .003$). The ANOVA results displayed in 6 showed that the “*Between groups and within groups*” values for all the chemical elements are significant at alpha level (significant level) of 0.05.

The laboratory tests of BeetSop preserves showed variable degrees of nutritional value. SWB and BPJ preserve had the highest three nutritional content each, with SWB having the highest content of phosphorus ($2031.71 \mu\text{g/g}$), potassium ($10132.76 \mu\text{g/g}$) and zinc ($276.46 \mu\text{g/g}$) and BPJ having the highest content in copper ($270.37 \mu\text{g/g}$), iron ($5208.24 \mu\text{g/g}$) and magnesium ($.270 \pm .045\%$). These nutrients play an important role in oxygen transportation, energy production, immune system function, bone and tooth formation, energy production, protein synthesis, muscle relaxation, blood pressure regulation,

heart rhythm, and cellular function including cell growth and repair. They are also necessary for fluid balance, nerve function, and muscle contractions, including the heartbeat. In essence, choosing SWB BeetSop preserve suggests that you are prioritizing a diet rich in essential nutrients that support overall health and well-being. This could potentially lead to improved energy levels, better immune function, and overall better quality of life. Generally, the scores of the nutritional value across the chemical elements had close related margin indicating that all samples possess adequate amount of nutritional value.

The present study's findings align with prior research conducted by Okudu and Umahi (2017), which examined the nutritional composition of soursop jam. Their study revealed that soursop jam is rich in protein, fat, ash, and carbohydrates. Furthermore, they emphasized the presence of essential minerals such as calcium, potassium, and magnesium, which significantly contribute to the nutritional value of the jam. The authors concluded that soursop jam represents a low-fat product with a moderate protein content and a notable presence of carbohydrates, making it a potentially valuable source of energy.

In line with the current study, Agbo et al. (2022) investigated the nutritional composition of soursop fruit pulp obtained from different geographical locations. Their results indicated higher levels of crude fat, fibre, protein, and carbohydrates in the pulp. This study supports the findings of the present research, highlighting the influence of geographical origin on the nutritional composition of soursop.

Notably, a study published in the Iombor, Olaitan, and Ede (2014) reported that freeze-dried soursop retained more nutrients compared to the

oven-dried counterpart. The freeze-dried samples exhibited higher levels of moisture, protein, fat, fibre, and ash. These results further reinforce the impact of preparation methods on the nutritional outcome of soursop products. Similarly, the differences observed in the nutritional value of the Beetsop samples in this study can be attributed to variations in processing techniques.

The presence of essential nutrients such as phosphorus, potassium, zinc, and magnesium in beetsop preserve aligns with the outcomes of several studies, emphasizing soursop's status as a rich source of these beneficial elements, which promote general health, prevent cell damage, and aid in wound healing (WebMD Editorial Contributors, 2020; Moghadamtousi et al., 2015). Furthermore, Nabilah (2013) conducted a proximate analysis of beetroot and observed that it serves as a significant source of moisture, ash, protein, fat, crude fibre, and carbohydrates, thus corroborating the findings of the current study.

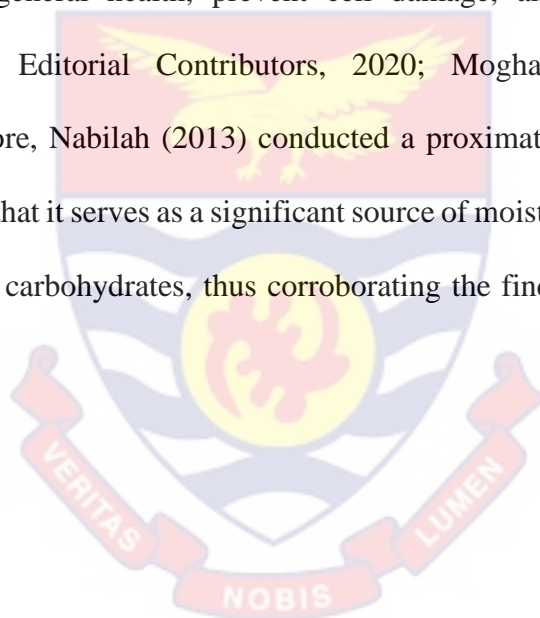


Table 4: Mineral Elements Constituent of BeetSop Jam

SAMPLE	P ug/g	K ug/g	Na ug/g	Cu ug/g	Zn ug/g	Fe ug/g	Ca %	Mg %
BPJ	2010.38 ± 10.08	5170.16 ± 2.64	1040.14 ± 39.26	270.37 ± .45	124.65 ± 2.66	5208.24 ± 78.06	1.40 ± .036	.270 ± .045
BAS	1915.08 ± 6.08	9293.19 ± 42.34	2114.22 ± 51.25	207.72 ± 2.58	257.73 ± 3.49	3288.59 ± 73.84	1.49 ± .035	.127 ± .035
SWB	2031.71 ± 21.97	10132.76 ± 272.37	1541.23 ± 49.69	156.01 ± 1.97	276.46 ± 5.15	3602.57 ± 109.21	1.31 ± .017	.139 ± .005
BWS	2020.19 ± 6.04	9237.59 ± 124.99	2142.49 ± 55.32	112.22 ± .31	242.91 ± 1.07	3357.19 ± 50.72	1.25 ± .059	.121 ± .003

Source: Opoku (2024)

Values are averages of triplicate determinations

Sample: (BPJ= Black plum, BAS = Beetroot and Soursop, SWB = Soursop with Beetroot & BWS = Beetroot with Soursop).

Data is represented as mean ± standard deviation

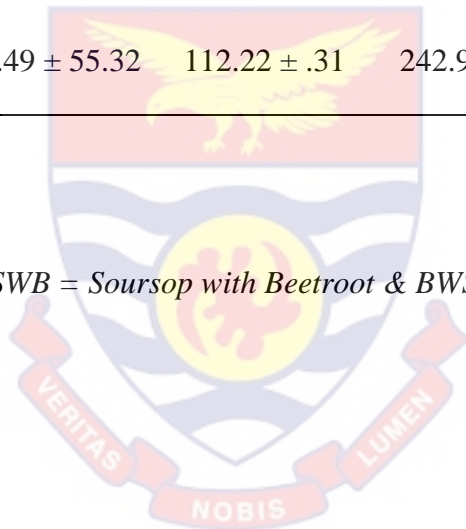


Table 5: ANOVA of Mineral Elements in Beetsop Jam

Mineral Elements		Sum of Squares	<i>f</i>	<i>D</i> Mean Square	F	Sig
Phosphorus ug/g	Between Groups	24782.48	2	12391.2	66.74	.000
	Within Groups	1113.92	6	185.65		
Potassium ug/g	Between Groups	1509315.19	2	754657.59	24.71	.001
	Within Groups	183212.64	6	30535.44		
Sodium ug/g	Between Groups	690634.09	2	345317.05	127.03	.000
	Within Groups	16310.94	6	2718.49		
Zinc ug/g	Between Groups	1696.68	2	848.34	63.89	.000
	Within Groups	79.67	6	13.28		
Copper ug/g	Between Groups	13718.66	2	6859.33	1936.99	.000
	Within Groups	21.25	6	3.54		
Iron ug/g	Between Groups	163503.32	2	81751.66	12.27	.008
	Within Groups	39990.79	6	6665.13		
Calcium %	Between Groups	.094	2	.047	28.54	.001
	Within Groups	.010	6	.002		
Magnesium %	Between Groups	.000	2	.000	18.37	.003
	Within Groups	.000	6	.000		

Source: Opoku (2024)

Significant $p < 0.05$



Research Question Three: To what extent do consumers accept the beetroot and soursop Jam?

Consumer Preferences and Overall Acceptability

Demographic characteristics of respondents

The study aimed to evaluate the preferred BeetSop preserve as a best jam spread among 80 participants. Participants tasted each sample and rated their subjective experiences using a 5-point Likert scale, ranging from 1 (like very much) to 5 (dislike very much). In the sensory evaluation study, gender and age distribution influence the results, as sensory perceptions can vary between these variables (Michon, 2010; Chambers, Lobb, Butler, & Traill, 2008). Ares and Gambaro (2007) study revealed that gender significantly impacts liking, attitude, affective response, choice, and perception of products. Beardsworth et al (2002) suggested that women utilize their senses and sensation experiences, while men may rely on cognitive alerts learned about a product, thus underscoring the need to ensure a significant representation of both gender for the best outcome.

Table 6: Distribution of Demographic Characteristic of Respondent

Variable	Sub-scale	Frequencies	Percentage%
Gender	Male	24	30.0
	Female	56	70.0
Total		80	100.0
Age (Years)	18	1	1.3
	19	11	13.8
	20	27	33.6
	21	15	18.8
	22	15	18.8
	23	6	7.5
	24	2	2.5
	25	3	3.8
Total		80	100.0

Source: Opoku (2024)

Sensory Evaluation of BeetSop Jam

The mean scores for appearance, taste, texture, aroma, and overall acceptability were analysed and presented in Table 7, revealing significant differences ($p < 0.05$) among the different preserves.

Appearance

The findings demonstrated that respondents' perceptions regarding the appearance of the samples ranged from 2.11 to 2.44. Among the samples, the appearance of SWB received the highest mean score (2.44, ± 0.84), indicating it was the most preferred in terms of visual appeal, followed by BWS (2.28 ± 0.86). Sample On the other hand, BPJ (control) received the lowest mean score (2.11 ± 0.63) followed by (2.15 ± 0.77), suggesting BPJ (control) was the least

preferred in terms of appearance. Thus, the results suggest that, among the four samples of preserve, SWB had the highest level of acceptance based on its appearance, as perceived by the respondents.

Taste

Regarding the taste evaluation of the BeetSop preserve samples, the taste of BWS received a comparatively higher rating (2.25 ± 0.86) compared to the other samples. The second highest was BAS (1.99 ± 0.82), then SWB (1.89 ± 0.87). Conversely, the taste that was the least preferred among the participants was the control BPJ (1.78 ± 0.54). It is noteworthy that the mean difference (MD) between the second-highest rated taste (BAS) and the least rated taste (BPJ) was minimal (MD = 0.21), while the mean difference between the most preferred sample (BWS) and the least preferred sample (BPJ) was 0.47. Overall, the mean differences suggest that there is no clear distinction in terms of taste between BAS and BPJ. While taste is a subjective experience, the responses from the majority of participants indicate that BWS is perceived as the best preserve in terms of taste.

Texture

Moreover, the participants' responses revealed that the sample with the most favourable texture was SWB with a mean score of 2.45 (SD = 0.84). Conversely, BAS was ranked the lowest in terms of texture with a mean score of 2.24 (SD = 0.80). Additionally, the mean difference between the most preferred sample, SWB, and the least preferred sample, BAS, regarding texture was 0.21. In contrast, the mean difference between the SWB and the second preferred sample BWS (2.41 ± 0.89) was only 0.04. This indicates that the

majority of participants preferred the texture of SWB slightly over other samples, indicating that it was more appealing and well-received.

Aroma

The sensory evaluation also encompassed the assessment of participants' preferences regarding aroma. The analysis indicated that the sample with a higher preference in terms of aroma was BWS (2.36 ± 0.87) followed by BAS (2.23 ± 0.87) then SWB (2.16 ± 1.05). Conversely, the sample with the least aroma preference was BPJ with a mean score of (1.92 ± 0.81). The mean difference between the most preferred and least preferred sample was 0.44.

Overall Acceptability

Participants were requested to indicate their overall acceptability of the three samples of BeetSop. The results of the analysis demonstrated that the most accepted preserve was BWS with a mean score of 2.34 (SD = 0.83). Following closely, SWB (2.14 ± 0.85) obtained a relatively high level of acceptance, then BAS (2.03 ± 0.72), while BPJ (1.95 ± 0.64) was the least preferred preserve formulation. These findings reinforce participants' preference for BWS in terms of taste and aroma. Interestingly, the overall analysis revealed that BPJ was not favoured across all the assessed attributes.

To conclude, the sensory evaluation results of the study demonstrate that the BWS received favourable attributes in terms of taste, aroma, and overall acceptability, making it the preferred choice among the participants. The SWB preserve also received positive responses, although to a slightly lesser extent compared to BWS. On the other hand, the BAS and BPJ combination did not receive strong preference in any of the evaluated aspects. Participants generally

found BPJ lacking in appearance, taste and aroma which contributed to its lower acceptability scores.

The study conducted by Jaiswal et al. (2022) demonstrated that the inclusion of jaggery in beetroot jam resulted in significant improvements in sensory attributes, particularly colour and taste, leading to higher consumer acceptability scores. These findings highlight that BWS with 75% beetroot content ranked highest in terms of taste and received the highest acceptability ratings. Similarly, the results of the present study align with those of Parn et al. (2015), who found that beetroot jam exhibited superior scores in terms of texture, flavour, and overall acceptability compared to beetroot pickle and powder.

Although not directly related to this study, Irshad (2020) conducted research aiming to enhance the nutritional value and consumer acceptability of jam by combining different ingredients. The results indicated that a combination of pineapple and carrot resulted in a highly acceptable jam, receiving favourable scores for flavour, texture, and overall acceptability. These findings suggest that the right combination of two or more fruits, such as beetroot and soursop, can yield unique and pleasant-tasting jam that appeal to consumers. While no specific study has explored the combination of beetroot and soursop, the findings of the current study support diverse results obtained from studies focusing on either of these fruits.

Table 7: Sensory Evaluations of Jam Produced from Different Proportion of Beetroot and Soursop

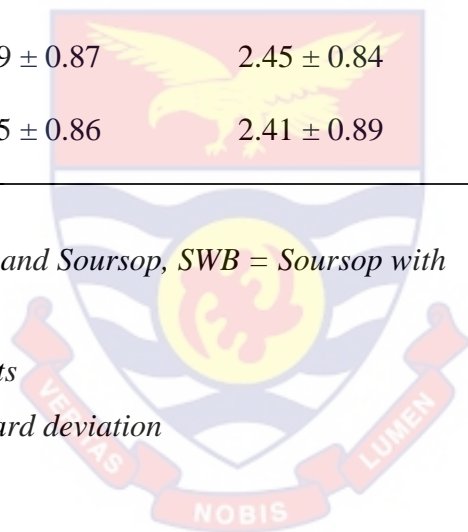
Attributes Samples	Appearance	Taste	Texture	Aroma	Overall Acceptability
BPJ	2.11 ± 0.63	1.78 ± 0.54	2.32 ± 0.82	1.92 ± 0.81	1.95 ± 0.64
BAS	2.15 ± 0.77	1.99 ± 0.82	2.24 ± 0.80	2.23 ± 0.87	2.03 ± 0.72
SWB	2.44 ± 0.84	1.89 ± 0.87	2.45 ± 0.84	2.16 ± 1.05	2.14 ± 0.85
BWS	2.28 ± 0.86	2.25 ± 0.86	2.41 ± 0.89	2.36 ± 0.87	2.34 ± 0.83

Source: Opoku (2024)

Sample: (BPJ= Black plum, BAS = Beetroot and Soursop, SWB = Soursop with Beetroot, & BWS = Beetroot with Soursop).

Values are averages of triplicate determinants

N = 80 Data is represented as mean ± standard deviation



Research Question Four: How long can the BeetSop Jam be kept without sensory quality changes?

Shelf-Life and Quality Attributes of BeetSop Jam

The objective of this study was to determine the sample of beetroot or soursop with the longest shelf life, characterized by minimal changes in quality attributes. The shelf-life analysis involved laboratory testing, where four microbial profiles (Aerobic Plate Count (APC), Total Coliform, Salmonella spp, and Yeast and Moulds) were examined. Each sample underwent a three-day examination, with three independent analyses conducted each day. Lower microbial counts generally indicate better quality and an extended shelf life. The results of the triplicate determination were subjected to SPSS analysis and are presented in Tables 7 and 8.

Aerobic Plate Count

The shelf life analysis results, as shown in Table 8, revealed that the APC values for the samples ranged between 21.28 CFU/ml and 584.78 CFU/ml. Among the samples, BPJ (21.28 ± 8.47) recorded the lowest value, It was followed by SWB (23.78 ± 4.49) then BAS (41.89 ± 16.83). BWS (584.78 ± 33.35) recorded the highest value. Low APC values indicate BPJ (control) had minimal microbial activity, indicating longer shelf life and better preservation of quality attributes, while higher APC values of the other preserves suggest shorter shelf life and faster degradation.

Total Coliform

The Total Coliform values ranged between 12.72 and 45.56. BPJ (12.72 ± 2.63) exhibited the lowest Total Coliform count, followed BAS (19.22 ± 2.44) then SWB (19.33 ± 1.80), while BWS had the highest count (45.56 ± 7.32). The

low Total Coliform count suggests that BPJ (control) has a lower risk of contamination by coliform bacteria, which is beneficial for extending shelf life.

Salmonella spp.

The *Salmonella spp.* content, determined during the three-day laboratory shelf life analysis, demonstrated values ranging from 1.04 to 3.67. BPJ had the longest shelf life in terms of *Salmonella spp.* (1.04 ± 1.29), followed by SWB (1.22 ± 1.56), then BWS (3.56 ± 1.51). BAS (3.67 ± 1.80) exhibited the shortest shelf life in terms of *Salmonella spp.* However, the analysis revealed that BAS and BWS had a relatively similar shelf life on this microbial profile, as the mean difference between them was 0.11.

Rhizopus stolonifer

The *Rhizopus stolonifer* values ranged between 136.42 and 202.78. The control BPJ (136.42 ± 21.36) demonstrated the longest shelf life among the four samples, followed by SWB (166.67 ± 15.75) then BAS (175.00 ± 18.53). BWS (202.78 ± 25.74) demonstrated the shortest shelf life. The ANOVA analysis results presented in Table 9 showed that the "Between groups and within groups" values for all microbial profiles were significant at an alpha level of 0.05. This indicates a significant difference among the samples in terms of microbial profile or shelf-life analysis.

Overall, the shelf-life analysis of the BeetSop samples revealed that the control BPJ had the longest shelf life compared to the other three samples. This is primarily due to BPJ's lower microbial profile scores across Aerobic Plate Count, Total Coliform, *Salmonella spp.*, and *Rhizopus stolonifer*. In essence, BPJ stands the chance of being kept for a longer period without sensory quality changes followed by SWB since it had the second lower microbial profile score

across Aerobic Plate Count, Salmonella spp, and Rhizopus stolonifer. Furthermore, the values of SWB and BAS were relatively similar in terms of Total Coliform, with a mean difference of 0.11, suggesting that SWB and BAS had a comparable shelf life in this specific microbial profile.

In comparison to the findings of this study, Ajibola et al. (2019) conducted research on beetroot jam and observed that the quality attributes of colour, taste, and texture can be effectively retained when the jam is stored under refrigeration. However, when stored at ambient temperature, a decline in sensory quality was observed after three months. Proper sealing and pasteurization were identified as crucial factors in preventing spoilage. While Ajibola and colleagues utilized both refrigeration and ambient storage conditions in their study, the current study specifically subjected the BeetSop preserve samples to ambient storage for three days. The results indicated that the BPJ combination had the longest shelf-life compared to the other combinations. This may be as a result of the sugar used in the preparation of the control BPJ. Sugar plays an important role in jam making and responsible for the sweet taste and act as preservative in addition to jell formation (Awulachew, 2021).

During the proximate analysis of the samples, it was noted that preserves with higher dry matter content, specifically BWS combination, had a longer shelf-life. However, the findings from research question four revealed that other factors such as type of sweetener, time, method of storage, sealing, and pasteurization, as disclosed in Ajibola's study, also have an impact on the shelf-life of jam. In this current study, the analysis focused on four microbial profiles,

namely, Aerobic Plate Count (APC), Total Coliform, *Salmonella* spp, and *Rhizopus stolonifer*, to determine the sample with the likely longest shelf-life.

Indeed, various factors can impact the storage life of BeetSop preserve and other jams, highlighting the importance of considering these factors during the preparation process. For instance, Mendes et al. (2020) discovered that adding lemon juice to soursop jam extended its shelf life and improved quality retention. Singh et al. (2018) found that storing beetroot jam at cooler temperatures resulted in better retention of its quality attributes. Dlamini et al. (2021) determined that vacuum-sealed pouches provided optimal preservation of sensory and nutritional qualities over a six-month period. Also, Rahman et al. (2022) found that beetroot jam made with honey exhibited a slightly longer shelf life and better retention of sensory qualities compared to those made with sucrose or stevia. In summary, the storage life of Beetsop jam and other jams can be influenced by a range of factors. It is essential to consider factors such as the addition of preservatives or natural acids, storage temperature, packaging methods (such as vacuum sealing), and the choice of sweeteners in order to prolong shelf life and retain sensory qualities effectively.

Table 8: Microbial Profile of Shelf life of BeetSop Jam Samples

SAMPLE	Aerobic Plate Count (CFU/ml)	Total Coliform	Salmonella spp	Rhizopus stolonifer
BPJ	21.28 ± 8.47	12.72 ± 2.63	1.04 ± 1.29	136.42 ± 21.36
BAS	41.89 ± 16.83	19.22 ± 2.44	3.67 ± 1.80	175.00 ± 18.53
SWB	23.78 ± 4.49	19.33 ± 1.80	1.22 ± 1.56	166.67 ± 15.75
BWS	584.78 ± 33.35	45.56 ± 7.32	3.56 ± 1.51	202.78 ± 25.74

Source: Opoku (2024)

Values are averages of triplicate determinations

Sample: (BPJ = Black plum, BAS = Beetroot and Soursop, SWB = Soursop with Beetroot, & BWS = Beetroot with Soursop).

Data is represented as mean ± standard deviation

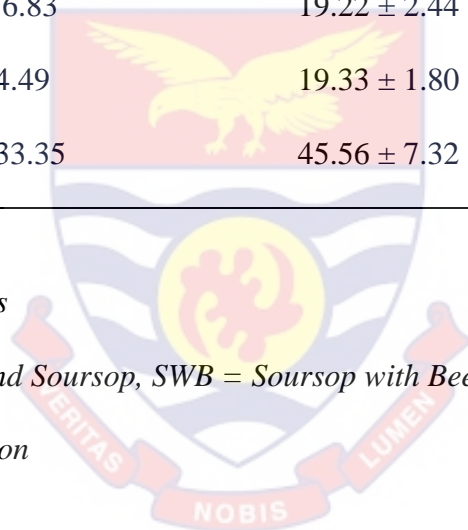


Table 9: ANOVA of Microbial Profile of Shelf-Life of Beetroot and Soursop Jam

		Sum of Squares	df	Mean Square	F	Sig
Aerobic Plate	Between Groups	1829332.07	2	914666.037	1937.85	.000
Count (CFU/ml)	Within Groups	11328.00	24	472.000		
Total Coliform	Between Groups	4143.19	2	2071.593	99.08	.000
	Within Groups	501.78	24	20.907		
Salmonella spp	Between Groups	34.30	2	17.148	6.45	.006
	Within Groups	63.78	24	2.657		
Rhizopus	Between Groups	6435.19	2	3217.593	7.70	.003
stolonifer	Within Groups	10031.56	24	417.981		

Source: Opoku (2024)

Significant $p < 0.05$

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Overview of the Study

This chapter provides a summary of the complete research project, taking into account the study's results in relation to its objectives. Additionally, recommendations are provided along with the study's conclusions. The purpose of this study was to explore, experiment, and create a jam made of beetroot and soursop in various ratios that is wholesome, nourishing, and convenient to use. The experimental research and descriptive designs were used to guide the study. Three spreads with varying amounts of soursop and beetroot were created as a result. BAS, SWB, and BWS are the three created BeetSop jam and a control BPJ making up the four samples that underwent proximate analysis and sensory evaluation.

The samples used for the proximate analysis was purchased at Kotokraba market (Cape Coast, Central Region). Eighty students from the Department of Vocational and Technical Education made up the sample size for the sensory analysis. On the several samples of BeetSop jam, laboratory tests for the following nutrients were also conducted: protein, calcium, carbohydrate, crude fibre, lipids, magnesium, zinc, potassium, sodium, iron, copper, and ash. The samples were subjected to microbial analysis is in order to detect the presence of yeasts and moulds, total coliforms, *Salmonella spp.*, and aerobic plate count using the standard plate count method.

The proximate analysis on the BeetSop jam was carried out in the School of Agriculture, University of Cape Coast (UCC). The microbiological analysis of BeetSop jam was carried out at the University of Cape Coast's Department

of Laboratory Technology. Findings from the proximate analysis, microbial analysis and sensory evaluation was analysed using Microsoft Excel where the mean and standard deviation were generated to determine the significant level at 95% confidence level ($p < 0.05$). The panellists' overall acceptance of the products was used to choose the products with a mean score of 1 to 2 designating acceptance and 3-5 designating rejection.

Summary of Key Findings

As stated in the first objective, it was feasible to produce three different preserves using a combination of beetroot, soursop, and dates. The samples were coded using abbreviations (BAS, SWB and BWS).

Sample "B" (BAS) which was made from 50% beetroot and 50% soursop.

Sample "C" (SWB) which was made from 75% soursop with 25% beetroot.

Sample "D" (BWS) which was made from 75% beetroot with 25% soursop.

For every **550g** of the sample, **350g** of date was added.

The BeetSop jam was found to contain seven major chemical elements: dry matter, moisture, ash, protein, fat/oil, fibre, and carbohydrates. It was deduced from the analysis that overall, the sample with the most quantity of chemical constituent was BWS having second highest values six chemical constituents (moisture ($70.63 \pm .198$), ash ($3.38 \pm .175$), protein ($7.31 \pm .026$), fat/oil ($.126 \pm .003$), fibre ($6.20 \pm .027$) and carbohydrate ($83.00 \pm .177$) and BAS with having highest values three chemical constituents, *Moisture* ($73.30 \pm .099$), *Protein* (7.63 ± 0.74), and *CHO* ($83.45 \pm .074$). Among the BeetSop preserve samples, the SWB and BPJ (control) preserve had the highest three nutritional content each, with SWB having the highest content of phosphorus ($2031.71 \mu\text{g/g}$), potassium ($10132.76 \mu\text{g/g}$) and zinc ($276.46 \mu\text{g/g}$) and BPJ

(control) having the highest content in copper ($270.37 \mu\text{g/g}$), iron ($5208.24 \mu\text{g/g}$) and magnesium ($.270 \pm .045\%$). and the BWS sample recorded the highest score in one element sodium (2142.49 ± 55.32).

The sensory evaluation revealed that the BWS received favourable attributes in terms of taste (2.25 ± 0.86), aroma (2.36 ± 0.87), and overall acceptability (2.34 ± 0.83), making it the preferred choice among the participants. The SWB jam also received positive responses, although to a slightly lesser extent compared to BWS. On the other hand, the BAS and BPJ combination did not receive strong preference in any of the evaluated aspects.

The SWB BeetSop jam had the second lower microbial profile score across Aerobic Plate Count (23.78 ± 4.49), Salmonella spp (1.22 ± 1.56), and Rhizopus stolonifer (166.67 ± 15.75). Furthermore, the values of SWB and BAS were relatively similar in terms of Total Coliform, with a mean difference of 0.11, suggesting that SWB and BAS had a comparable shelf life in this specific microbial profile.

Conclusions

The findings of this study indicate that an innovative jam can be successfully developed by combining beetroot, soursop, and dates, offering enhanced nutritional value and high consumer acceptability.

The BeetSop preserve demonstrates a unique nutritional profile, making it a valuable addition to a healthy diet. The variation in nutrient content among the different samples, attributed to the modulation of ingredient ratios, highlights the importance of optimizing formulation parameters to achieve consistent nutritional quality. This finding underscores the potential for tailored formulation of BeetSop jam to meet specific nutritional needs or targets.

SWB formulation being the most well-received among the taste panel, exhibiting superior taste, aroma, and overall acceptability. This finding suggests that the specific combination and ratio of beetroot, soursop, and dates in the SWB formulation may be optimal for achieving a desirable sensory profile. This information can be used to inform the development of a commercially viable BeetSop jam product that meets consumer preferences.

The finding that SWB BeetSop jam recorded a relatively low microbial load, with notable control over *Aerobic Plate Count*, *Salmonella spp*, and *Rhizopus stolonifera* and the fact comparable Total Coliform counts were observed between SWB and BAS suggest that these formulations may have similar shelf life potentials. These findings imply that the BeetSop jam formulations, particularly SWB, demonstrate satisfactory microbiological quality, which is a critical factor in ensuring the safety and stability of the product.

Recommendations

The conclusions have led to the following recommendations being made.

1. Further experiments should be conducted to optimize the ingredient ratios to achieve consistent nutritional quality and desirable sensory profiles.
2. The SWB formulation which demonstrated superior sensory attributes and satisfactory microbiological quality, is recommended as a promising candidate for commercialization. However, the shelf life study should be extended to confirm the stability and safety of the BeetSop preserve formulations, particularly SWB and BAS.

3. BeetSop preserve formulations could be tailored to meet specific nutritional needs or targets, such as for individuals with dietary restrictions or requirements.
4. Sensory evaluations with a larger and more diverse panel is important to validate the findings and ensure the product meets consumer preferences.

Suggested area for Further Studies

1. This study's scope is limited to the University of Cape Coast in Ghana's Central Region; therefore, it should be broadened to cover a greater area outside of the region's universities.
2. A study to investigate advanced preservation techniques to extend the shelf life of BeetSop jam, focusing on natural preservatives, innovative packaging, and storage conditions for optimal quality.
3. Conduct comparative studies on BeetSop jam and other fruit preserves to highlight their unique benefits, including nutritional comparisons, sensory evaluations, and consumer preference studies.
4. Research Can be conducted to thoroughly examine the microbial profile of BeetSop jam to ensure food safety and regulatory compliance

REFERENCES

- Abdel Moneim E, S., Abd, I. A., & Awad M, A. (2012). Comparative study on five Sudanese date (*Phoenix dactylifera* L.) fruit cultivars. *Food and Nutrition Sciences*, 2012.
- Afzaal, M., Saeed, F., Asghar, A., Shah, Y. A., Ikram, A., Ateeq, H., ... & Chacha, J. S. (2022). Nutritional and therapeutic potential of soursop. *Journal of Food Quality*, 2022(1), 8828358.
- Agbo, E. A., Ogbonna, W. O., Osadebe, V. O., & Aba, S. C. (2022). Location influenced nutritional composition of some accessions of *Annona muricata* (Soursop) fruit pulp. *Nigerian Journal of Horticultural Science*, 25(3), 57-66.
- Agbo, R. I., Vihotogbé, R., Missihoun, A. A., Dagba, R. A., Assogbadjo, A. E., & Agbangla, C. (2022). Indigenous knowledge of *Detarium microcarpum* Guill. & Perr.(Caesalpiniaceae) and implication for conservation in Benin (West Africa). *Environment, Development & Sustainability*, 22(7).
- Ajibola, A. O., Onabanjo, O. O., & Olusanya, J. O. (2019). Shelf life and quality retention of beetroot jam during storage. *Journal of Food Science and Technology*, 56(7), 3310-3320. <https://doi.org/10.1007/s13197-019-03834-6>
- Akomolafe, S. F., & Ajayi, O. B. (2015). A comparative study on antioxidant properties, proximate and mineral compositions of the peel and pulp of ripe *Annona muricata* (L.) fruit. *International Food Research Journal*, 22(6).

- Aksay, S., Tokbaş, H., Arslan, R., & Çınar, F. (2018). Some Physicochemical Properties of the Whole Fruit Mandarin Jam. *Turkish Journal of Agriculture: Food Science and Technology*, 6, 632-635. <https://doi.org/10.24925/TURJAF.V6I5.632-635.1948>.
- Alagöz, S., Türkyılmaz, M., Tağı, Ş., & Özkan, M. (2015). Effects of different sorbic acid and moisture levels on chemical and microbial qualities of sun-dried apricots during storage. *Food Chemistry*, 174, 356-364.
- Albala, K. (Ed.). (2011). *Food Cultures of the World Encyclopaedia*. Vol. 4. Bloomsbury Publishing USA.
- Allen, S. E., Grimshaw, H. M., Parkinson, J. A., & Quarmby, C. (1974). *Chemical analysis of ecological materials* (pp. xii+-565).
- Almadini, A. M., Ismail, A. I., & Ameen, F. A. (2021). Assessment of farmers practices to date palm soil fertilization and its impact on productivity at Al-Hassa oasis of KSA. *Saudi Journal of Biological Sciences*, 28(2), 1451-1458.
- Alsabeelah, N. (2024). Beta Vulgaris L. Roots: A Review of its Phytochemistry, Nutritional Potential and Pharmacology. *Latin American Journal of Pharmacy: A Life Science Journal*, 43(1), 204-224.
- Al-Shahib, W., & Marshall, R. J. (2003). The fruit of the date palm: its possible use as the best food for the future?. *International Journal of Food Sciences and Nutrition*, 54(4), 247-259.
- Alsuhaibani, A. (2013). Biscuits fortified with red beetroot: Nutritional and sensory properties. *Journal of Food Science and Technology*, 50(5), 1234-1240. <https://doi.org/xx.xxx/jfst.2013.03.011>

- Andronoiu, D. G., Stănciuc, N., Muresan, C., & Râpeanu, G. (2022). Beetroot by-product as a functional ingredient for obtaining value-added mayonnaise. *Processes*, *10*(2), 227.
<https://doi.org/10.3390/pr10020227>
- Anhwere, Y. M. (2009). *Assessment practices of teacher training college tutors in Ghana*. (Doctoral dissertation, University of Cape Coast).
- AOAC (2008). *Official method of analysis*. Association of Official Analytical Chemists, Maryland: AOAC International.
- Araujo, Q. R. De, Gattward, J. N., Almoosawi, S., Parada Costa Silva, M. das G. C., Dantas, P. A. D. S., & Araujo Júnior, Q. R. De. (2016). Cocoa and Human Health: From Head to Foot—A Review. *Critical Reviews in Food Science and Nutrition*, *56*(1), 1–12.
<https://doi.org/10.1080/10408398.2012.657921>
- Ares, G., & Gámbaro, A. (2007). Influence of gender, age and motives underlying food choice on perceived healthiness and willingness to try functional foods. *Appetite*, *49*, 148-158.
<https://doi.org/10.1016/j.appet.2007.01.006>
- Areta, J. L., Burke, L. M., Ross, M. L., Camera, D. M., West, D. W., Broad, E. M., ... & Coffey, V. G. (2013). Timing and distribution of protein ingestion during prolonged recovery from resistance exercise alters myofibrillar protein synthesis. *The Journal of Physiology*, *591*(9), 2319-2331.
- Ashraf, Z., & Hamidi-Esfahani, Z. (2011). Date and date processing: a review. *Food Reviews International*, *27*(2), 101-133.

- Awulachew, M. (2021). Fruit jam production. *International Journal of Food Science, Nutrition and Dietetics*, 10(4), 532-537.
- Aydeniz-Güneşer, B. (2022). Valorization of date palm (*Phoenix dactylifera*) wastes and by-products. In *Mediterranean Fruits Bio-wastes* (pp. 391-402). Springer, Cham.
- Azimont, F., & Araujo, L. (2014). Credible qualifications: The case of functional foods. In *Concerned Markets* (pp. 129-152). Edward Elgar Publishing.
- Badrie, N., & Schauss, A. G. (2010). Soursop (*Annona muricata* L.): composition, nutritional value, medicinal uses, and toxicology. In *Bioactive foods in promoting health* (pp. 621-643). Academic Press.
- Baker, M. T., Lu, P., Parrella, J. A., & Leggette, H. R. (2022). Consumer Acceptance toward Functional Foods: A Scoping Review. *International Journal of Environmental Research and Public Health*, 19(3), 12-17.
<https://doi.org/10.3390/IJERPH19031217>
- Bangar, S., Sharma, N., Sanwal, N., Lorenzo, J. M., & Sahu, J. K. (2022). Bioactive potential of beetroot (*Beta vulgaris*). *Food Research International*, 158. <https://doi.org/10.1016/J.FOODRES.2022.111556>
- Barrow, S. C. (1998). A monograph of phoenix L.(palmae: Coryphoideae). *Kew Bulletin*, 513-575.
- Beardsworth, A., Bryman, A., Keil, T., Goode, J., Haslam, C., & Lancashire, E. (2002). Women, men and food: the significance of gender for nutritional attitudes and choices. *British Food Journal*, 104, 470-491.
<https://doi.org/10.1108/00070700210418767>.

- Beckeman, M., & Skjöldebrand, C. (2007). Clusters/networks promote food innovations. *Journal of Food Engineering*, 79(4), 1418-1425.
- Benner, M. (2005). *The chain information model: a systematic approach for food product development*. Wageningen University and Research.
- Bernard, H. R. (2017). *Research methods in anthropology: Qualitative and quantitative approaches*. (6th ed.). Rowman & Littlefield.
- Biancardi, E., Panella, L. W., Lewellen, R. T., Biancardi, E., Panella, L. W., & Lewellen, R. T. (2012). History and current importance. *Beta maritima: The Origin of Beets*, 1-74.
- Blake, S., Launsby, R. G., & Weese, D. L. (1994). Experimental design meets the realities of the 1990s. *Quality progress*, pp. 99-101
- Bloch, C. (2007). Assessing recent developments in innovation measurement: the third edition of the Oslo Manual. *Science and Public Policy*, 34(1), 23-34.
- Bonavia, D., Ochoa, C. M., Óscar Tovar, S., & Palomino, R. C. (2004). Archaeological evidence of cherimoya (*Annona cherimolia* Mill.) and guanabana (*Annona muricata* L.) in ancient Peru. *Economic Botany*, 58(4), 509-522.
- Bowler, P., Loh, V. Y., & Marsh, R. A. (1995). *Preserves and jellies*. In *Physico-Chemical Aspects of Food Processing* (pp. 315-331). Boston, MA: Springer US.
- Britton, N. L., & Wilson, P. (1924). Scientific Survey of Porto Rico and the Virgin islands, Volume V, Botany of Porto Rico and the Virgin Islands, Pandanales to Thymeleales. *Scientific Survey of Porto Rico and the*

Virgin islands, Volume V, Botany of Porto Rico and the Virgin Islands, Pandanales to Thymeleales.

- Bunkar, D. S., Anand, A., Meena, K. K., Goyal, S. K., & Paswan, V. K. (2020). Development of production technology for preparation of beetroot powder using different drying methods. *Annals of Phytomedicine*, 9(2), 293-301.
- Chambers, S., Lobb, A., Butler, L., & Traill, W. (2008). The influence of age and gender on food choice: a focus group exploration. *International Journal of Consumer Studies*, 32, 356-365.
<https://doi.org/10.1111/J.1470-6431.2007.00642.X>.
- Chang, L. S., Karim, R., Abdulkarim, S. M., & Ghazali, H. M. (2018). Production and characterization of enzyme-treated spray-dried soursop (*Annona muricata* L.) powder. *Journal of Food Process Engineering*, 41(5), e12688.
- Chao, C. T., & Krueger, R. R. (2007). The date palm (*Phoenix dactylifera* L.): overview of biology, uses, and cultivation. *HortScience*, 42(5), 1077-1082.
- Chaudhari, S., & Nikam, M. (2015). Development and sensory analysis of beetroot jelly. *International Journal of Science and Research*, 4(3), 827-830.
- Chauhan, S., Chamoli, K., & Sharma, S. (2020). Beetroot-A review paper. *Journal of Pharmacognosy and Phytochemistry*, 9(2S), 424-427.
- Chen, M. F. (2011). The joint moderating effect of health consciousness and healthy lifestyle on consumers' willingness to use functional foods in

Taiwan. *Appetite.*, 57(1), 253–262.

<https://doi.org/10.1016/j.appet.2011.05.305>

Chen, Y. C., Lee, C. S., Tsui, P. L., & Chiang, M. C. (2021). The application of the analytic hierarchy process approach to the inheritance of local delicious food culture and development of sustainable innovations. *Agronomy*, 12(3), 660.

Chouhan, S. (2015). Enumeration and identification of standard plate count bacteria in raw water supplies. *IOSR Journal of Environmental Science, Toxicology and Food Technology*, 9(2), 67-73.

Clarke, M. A. (1997). Sugars in food processing: A wide range of valuable properties for baking and confectionery. *International Sugar Journal*, 99(1179), 114-126.

Clifford, T., Howatson, G., West, D. J., & Stevenson, E. J. (2015). The potential benefits of red beetroot supplementation in health and disease. *Nutrients*, 7(4), 2801-2822.

Coleman, J., Berry, D. P., Pierce, K. M., Brennan, A., & Horan, B. (2010). Dry matter intake and feed efficiency profiles of 3 genotypes of Holstein-Friesian within pasture-based systems of milk production. *Journal of Dairy Science*, 93(9), 4318-4331.

Coria-Téllez, A. V., Montalvo-González, E., Yahia, E. M., & Obledo-Vázquez, E. N. (2018). *Annona muricata*: A comprehensive review on its traditional medicinal uses, phytochemicals, pharmacological activities, mechanisms of action and toxicity. *Arabian Journal of Chemistry*, 11(5), 662-691.

- Coronel, R. E. (1983). *Promising Fruits in the Philippines*. Los Banos, Philippines: College of Agriculture, University of the Philippines.
- Daher, A., Mohamed, N., & Aberlenc-Bertossi, F. (2015). Date palm status and perspective in Djibouti. *Date Palm Genetic Resources and Utilization: Volume 1: Africa and the Americas*, 429-444.
- Davidson, A. (2014). *The oxford companion to food*. Oxford University Press.
- DeGregorio, M. (2007). Fruit Preserves and Jellies. *Kirk-Othmer Encyclopedia of Chemical Technology*.
<https://doi.org/10.1002/0471238961.FRUIDEGR.A01>.
- DeGregorio, M. L. (2000). Fruit preserves and jellies. *Kirk-Othmer Encyclopedia of Chemical Technology*.
- Dhadage, K., Shinde, G., & Gadhave, R. (2015). Development of the functional food i.e., beetroot fortified multi grain snacks. *International Journal of Science and Research*, 4(5), 469–473.
- Dhawan, D., Sharma, S., & Scholar, D. (2019). Exploration of the nourishing, antioxidant and product development potential of beetroot (*Beta vulgaris*) flour. *International Journal of Health Sciences & Research* ([Www.ijhsr.org](http://www.ijhsr.org)), 9(6), 280.
- Dlamini, N. P., Zikalala, N. P., & Mabunda, S. M. (2021). Influence of packaging materials on the shelf life of soursop jam. *Journal of Food Packaging and Preservation*, 38(3), 210-223.
<https://doi.org/10.1002/jfpp.2021.31012>
- Dowson, V. H. (1982). Date Production and Protection (Plant Production and Protection Paper No. 35). *FAO Food and Agriculture Organization of the United Nations, Rome, Italy*.

- Dubey, K. K., Mishra, S. S., Marathe, S. J., Mahajani, S. M., Arora, A., & Singhal, R. S. (2022). Incorporation of jaggery in beetroot jam enhances its antioxidant properties with acceptable sensory and physicochemical profile. *Food and Humanity, 1*, 985-995.
- Dwivedi, S. K., Issar, K., & Tiwari, V. (2023). Nutrient Requirements in Health and Disease. In *Handbook of Nutraceuticals: Science, Technology and Engineering* (pp. 1-26). Cham: Springer International Publishing.
- Eke-Ejiofor, J., Allen, J. E. & Ekeolisa, I. C. (2019). Physicochemical, Sensory Properties and Bacteria Load of Jam Produced from Squash (Cucurbita) Fruit. *Food Science & Nutrition Technology*.
<https://doi.org/10.23880/fsnt-16000187>.
- El-Deek, A. A., Attia, Y. A., & Al-Harhi, M. A. (2010). Whole inedible date in the grower–finisher broiler diets and the impact on productive performance, nutrient digestibility and meat quality. *Animal, 4*(10), 1647-1652.
- El-Juhany, L. I. (2010). Degradation of date palm trees and date production in Arab countries: causes and potential rehabilitation. *Australian Journal of Basic and Applied Sciences, 4*(8), 3998-4010.
- Eusala, D., & Pendon, G. (2016). Palatability and Sensory Perception of Soursop (Annona Muricata) Tart Filling With Jute (Corchorus Olitorious) Leaves. *IRA International Journal of Education and Multidisciplinary Studies* (ISSN 2455–2526), 3(3), 436–445.
<https://doi.org/10.21013/jems.v3.n3.p15>

- FAO. (2011). Overview of date fruit production, postharvest handling, processing, and nutrition. *Dates: Postharvest science, processing technology and health benefits*, 1-28.
- FAO. (2020). *FAOSTAT*. Food and Agriculture Organization of the United Nations.
- Fernández-López, J., Ponce-Martínez, A. J., Rodríguez-Párraga, J., Solivella-Poveda, A. M., Fernández-López, J. A., Viuda-Martos, M., & Pérez-Alvarez, J. A. (2023). Beetroot juices as colorant in plant-based minced meat analogues: Color, betalain composition and antioxidant activity as affected by juice type. *Food Bioscience*, 56, 103156. <https://doi.org/10.1016/j.fbio.2023.103156>
- Fisk, K. (2023). 10 amazing benefits of beetroot. *Bare Biology*. <https://www.barebiology.com/blogs/news/10-amazing-benefits-of-beetroot>.
- Free, J. B., Williams, I. H., Longden, P. C., & Johnson, M. G. (1975). Insect pollination of sugar-beet (*Beta vulgaris*) seed crops. *Annals of Applied Biology*, 81(2), 127-134.
- Gadekar, R., Kadam, P. S., & Gokhale, S. (2016). Studies on Preparation and Storage of Beetroots Products. *International Journal for Research in Applied Science and Engineering Technology (IJRASET)*, 4(5), 189-194.
- Garcia, R., & Calantone, R. (2002). A critical look at technological innovation typology and innovativeness terminology: a literature review. *Journal of Product Innovation Management: An international publication of the product development & management association*, 19(2), 110-132.

- García-Martínez, E., Ruiz-Díaz, G., Martínez-Monzó, J., Camacho, M., Martínez-Navarrete, N., & Chiralt, A. (2002). Jam manufacture with osmodehydrated fruit. *Food Research International*, 35, 301-306. [https://doi.org/10.1016/S0963-9969\(01\)00200-9](https://doi.org/10.1016/S0963-9969(01)00200-9)
- George, V. C., Kumar, D. N., Suresh, P. K., & Kumar, R. A. (2015). Antioxidant, DNA protective efficacy and HPLC analysis of *Annona muricata* (soursop) extracts. *Journal of Food Science and Technology*, 52, 2328-2335.
- Georgiev, V. G., Weber, J., Kneschke, E. M., Denev, P. N., Bley, T., & Pavlov, A. I. (2010). Antioxidant activity and phenolic content of betalain extracts from intact plants and hairy root cultures of the red beetroot *Beta vulgaris* cv. Detroit dark red. *Plant Foods for Human Nutrition*, 65(2), 105-111.
- Godfray, H. C. J., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., Nisbett, N., & Whiteley, R. (2010). The future of the global food system. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365(1554), 2769-2777.
- González, E. M., Fernández, A. E. L., Sáyago-Ayerdi, S. G., Estrada, R. M. V., & Vallejo, L. G. Z. (2017). In vitro antioxidant capacity of crude extracts and acetogenin fraction of soursop fruit pulp. *Pharm. Anal. Acta*, 8, 1-7.
- Grunert, K. G. (2005). Food quality and safety: consumer perception and demand. *European Review of Agricultural Economics*, 32(3), 369-391.

- Grunert, K. G., & van Trijp, H. C. (2014). Consumer-oriented new product development. *Encyclopedia of Agriculture and Food Systems*, 2, 375-386.
- Gyesi, J. N., Opoku, R., & Borquaye, L. S. (2019). Chemical composition, total phenolic content, and antioxidant activities of the essential oils of the leaves and fruit pulp of *Annona muricata* L. (Soursop) from Ghana. *Biochemistry Research International*, 2019.
- Haider, M. S., Khan, I. A., Jaskani, M. J., Naqvi, S. A., Mateen, S. A. J. I. D., Shahzad, U., & Abbas. (2018). Pomological and biochemical profiling of date fruits (*Phoenix dactylifera* L.) during different fruit maturation phases. *Pakistan Journal of Botany*, 50(3), 1069-1076.
- Hardoko Y.H., Halim Y., Wijoyo S.V. (2015). In Vitro Antidiabetic Activity of “Green Tea” Soursop Leaves Brew through α -Glucosidase Inhibition. *Int. J. PharmTech Res.*, 8, 30–37.
- Hawkins, W. (2019) (n.d.). 12 health benefits of beetroot. <https://www.pushdoctor.co.uk/nutrition-advice/health-benefits-of-beetroot>
- Henry-Unaeze, H. (2021). Evaluation of the chemical composition and sensory properties of soursop (*Annona muricata*) and watermelon (*Citrullus lanatus*) fruit juices and blends. *Journal of Dietitians Association of Nigeria*, 12, 2635–3326. <https://doi.org/10.4314/jdan.v12i1.2>
- Heymann, H., & Lawless, H. T. (2013). *Sensory evaluation of food: Principles and practices*. Springer Science & Business Media.
- Hughner, R. S., McDonagh, P., Prothero, A., Shultz, C. J., & Stanton, J. (2007). Who are organic food consumers? A compilation and review of why

- people purchase organic food. *Journal of Consumer Behaviour: An International Research Review*, 6(2-3), 94-110.
- IITA (1985). *Laboratory Manual of selected Methods for soil and Plant Analysis*. IITA, Ibadan.
- Imbahale, R. K. (2020). *Quality Characteristics of Fruit Jams and Marmalades Containing Gum Arabic Fromacacia Senegal Var. Kerensis* (Doctoral dissertation, Egerton University).
- Ingle, M., Nimbalkar, S. S., & Nawkar, R. (2017). Nutritional evaluation of cookies enriched with beetroot (*Beta vulgaris* L.) powder. *International Journal of Current Microbiology and Applied Sciences*, 6(5), 1888–1896.
- Ingle, M., Thorat, S. S., Kotecha, P. M., & Nimbalkar, C. A. (2017). Nutritional assessment of beetroot (*Beta vulgaris* L.) powder cookies. *Asian Journal of Dairy & Food Research*, 36(3).
- Iombor, T. T., Olaitan, I. N., & Ede, R. A. (2014). Proximate composition, antinutrient content and functional properties of soursop flour as influenced by oven and freeze drying methods. *Current Research in Nutrition and Food Science Journal*, 2(2), 106-110.
- Irshad, Z., Hanif, M. A., Ayub, M. A., & Jilani, M. I. (2020). Development and sensory evaluation of pineapple and carrot blend jam. *Med. Plants South Asia*, 341–354.
- Jaiswal, S., Dhillon, B., Sodhi, N. S., & Sogi, D. S. (2022). Physico-chemical, antioxidant, textural and sensory analyses of jelly bars formulated with the incorporation of beetroot extract and guava pectin. *Journal of Food Measurement and Characterization*, 16(4), 2801-2810.

- Janick, J., & Paull, R. E. (Eds.). (2008). The encyclopedia of fruit & nuts. CABI.
International Research Journal of Pharmacy, 7(6), 1-4.
- Jasmitha, S. K., Shenoy, A., & Hegde, K. (2018). A review on Beta Vulgaris (beet root). *International Journal of Pharma and Chemical Research*, 4(2), 136-140.
- Jeffery, E. (2005). Component interactions for efficacy of functional foods. *The Journal of Nutrition*, 135(5), 1223-1225.
- Jennifer, A. D., Lucretia, I. B., Monday O. A., Patience C. E. (2023). Physicochemical, microbial and sensory properties of Lactobacillus acidophilus fermented soursopbeetroot (Anona muricata – Beta vulgaris) beverage. *International Journal of Food Science and Nutrition*, 25(8), 44-82.
- Johnston, J., & Baumann, S. (2014). *Foodies: Democracy and distinction in the gourmet foodscape*. Routledge.
- Jribi, S., Ouhaibi, M., Boukhris, H., Damergi, C., & Debbabi, H. (2021). Formulations of low-sugar strawberry jams: quality characterization and acute post-prandial glycaemic response. *Journal of Food Measurement and Characterization*, 15(2), 1578-1587.
- Kadereit, G., Hohmann, S., & Kadereit, J. W. (2006). A synopsis of Chenopodiaceae subfam. Betoideae and notes on the taxonomy of Beta. *Willdenowia*, 9-19.
- Kenoyer, J. M., & Heuston, K. B. (2005). The World in Ancient Times.
- Kim, M. (2016). Dietary Sodium Intake in Patients with Type 2 Diabetes Mellitus. *Diabetes & Metabolism Journal*, 40, 280 - 282.
<https://doi.org/10.4093/dmj.2016.40.4.280>.

- Knekt, P., Kumpulainen, J., Järvinen, R., Rissanen, H., Heliövaara, M., Reunanen, A., & Aromaa, A. (2002). Flavonoid intake and risk of chronic diseases. *The American Journal of Clinical Nutrition*, 76(3), 560-568.
- Kongor, J. E., de Pascual-Teresa, S., Owusu, M., Kyei-Baffour, V. O., & Oduro-Yeboah, C. (2024). Investigating the effect of red beetroot powder concentration and processing time on the bioactive compounds composition and antioxidant capacity of beetroot dark chocolate. *Journal of the Science of Food and Agriculture*, 104(1), 184–195. <https://doi.org/10.1002/JSFA.12902>;CTYPE:STRING:JOURNAL
- Krueger, R. (1995). Mystique of the date palm links old and new worlds. *Diversity Plant Genetic Resources Journal*.
- Krueger, R. (2001, June). Date palm germplasm: overview and utilization in the USA. In *Proc. International Conference on Date Palms*.
- Lawless, H. T., & Heymann, H. (2013). *Sensory evaluation of food: principles and practices*. Springer Science & Business Media.
- Lazăr, S., Constantin, O. E., Horincar, G., Andronoiu, D. G., Stănciuc, N., Muresan, C., & Râpeanu, G. (2022). Beetroot by-product as a functional ingredient for obtaining value-added mayonnaise. *Processes*, 10(2), 2-27.
- Leatemia, J. A., & Isman, M. B. (2004). Insecticidal activity of crude seed extracts of *Annona* spp., *Lansium domesticum* and *Sandoricum koetjape* against lepidopteran larvae. *Phytoparasitica*, 32, 30-37.
- Lema-Pérez, L. (2021). Main organs involved in glucose metabolism. *Sugar intake-risks and benefits and the global diabetes epidemic*, 1-15.

- Lenoir, M., Serre, F., Cantin, L., & Ahmed, S. H. (2007). Intense sweetness surpasses cocaine reward. *PloS One*, 2(8), e698.
- Liogier, A. H., & Martorell, L. F. (2000). *Flora of Puerto Rico and adjacent islands: A systematic synopsis*. La Editorial, UPR.
- Mabo-El-Saad, M., & MS Shawir, S. (2024). Nutritional and Medicinal Value of Mineral Elements in Dates. *The Egyptian Science Magazine*, 11(1), 43-51.
- Magnuson, B., Munro, I., Abbot, P., Baldwin, N., Lopez-Garcia, R., Ly, K., & Socolovsky, S. (2013). Review of the regulation and safety assessment of food substances in various countries and jurisdictions. *Food Additives & Contaminants: Part A*, 30(7), 1147-1220.
- Maheswari, T. U., & Sinduja, S. (2020). Soursop: A promising fruit for cancer mitigation. *Plant Archives*, 20(1), 1653-1656.
- Maqsood, S., Adiamo, O., Ahmad, M., & Mudgil, P. (2020). Bioactive compounds from date fruit and seed as potential nutraceutical and functional food ingredients. *Food Chemistry*, 308, 125522.
- Mathangi, S., & Balasaraswathi, M. (2019). Formulation of horsegram cake enriched with beetroot powder. *International Journal of Applied Home Science*, 6(1), 61-5.
- McNamee, G. (2015). Jelly vs. Jam. *Virginia Quarterly Review*, 91, 223 - 223.
- Mendes, J. A., Carvalho, L. M., & Barbosa, M. I. (2020). Effect of natural preservatives on the shelf life and quality of soursop jam. *Food Preservation Science*, 45(4), 278-289.
- <https://doi.org/10.1016/j.foodpresci.2020.104-7>

- Meyer, R. S., & Purugganan, M. D. (2013). Evolution of crop species: genetics of domestication and diversification. *Nature Reviews Genetics*, *14*(12), 840-852.
- Michon, C., O'Sullivan, M., Sheehan, E., Delahunty, C., & Kerry, J. (2010). Investigation of the influence of age, gender and consumption habits on the liking of jam-filled cakes. *Food Quality and Preference*, *21*, 553-561. <https://doi.org/10.1016/J.FOODQUAL.2010.03.001>.
- Misra, V., & Shrivastava, A. K. (2022). *Understanding the Sugar Beet Crop and Its Physiology*. In *Sugar Beet Cultivation, Management and Processing* (pp. 11-25). Singapore: Springer Nature Singapore.
- Mitrevski, J., Pantelić, N., Dodevska, M. S., Kojić, J. S., Vulić, J. J., Zlatanović, S., Gorjanović, S., Laličić-Petronijević, J., Marjanović, S., & Antić, V. V. (2023). Effect of Beetroot Powder Incorporation on Functional Properties and Shelf Life of Biscuits. *Foods*, *12*(2). <https://doi.org/10.3390/FOODS12020322>
- Moghadamtousi, S. Z., Rouhollahi, E., Hajrezaie, M., Karimian, H., Abdulla, M. A., & Kadir, H. A. (2015). *Annona muricata* leaves accelerate wound healing in rats via involvement of Hsp70 and antioxidant defence. *International Journal of Surgery*, *18*, 110–117. <https://doi.org/10.1016/j.ijsu.2015.03.026>
- Mohamed, Z., Ismaiel, G., & Rizk, A. E. (2016). Quality characterizations of pasta fortified with red beet root and red radish. *International Journal of Food Science and Technology*, *1*(3), 1–7.
- Moreira, L. D. S. G., Fanton, S., Cardozo, L., Borges, N. A., Combet, E., Shiels, P. G., ... & Mafra, D. (2021). Pink pressure: beetroot (*Beta vulgaris*

- rubra) as a possible novel medical therapy for chronic kidney disease. *Nutrition Reviews*, 80(5), 1041-1061. *Nutrition reviews*. <https://doi.org/10.1093/nutrit/nuab074>.
- Morris, W. C. (2004). Low or no sugar in jams, jellies and preserves. *SP325-F, Agricultural Extension Service, University of Tennessee, Knoxville, TN*.
- Morton, J. F. (1987). *Soursop*. In *Fruits of Warm Climates*. Greensboro, NC: Media Incorporated, (pp. 75–80).
- Mouritsen, O. G., & Styrbæk, K. (2017). *Mouthfeel: how texture makes taste*. Columbia University Press.
- Mridula, D., Gupta, R., Bhadwal, S., Khaira, H., & Tyagi, S. (2016). Optimization of food materials for development of nutritious pasta utilizing groundnut meal and beetroot. *International Journal of Food Science and Technology*, 53(7), 1834–1844.
- Muinos, L. (2023, August 17). 7 Potential health benefits of dates. EverydayHealth.com. <https://www.everydayhealth.com/diet-nutrition/potential-health-benefits-of-dates/>
- Mutakin, M., Fauziati, R., Fadhillah, F. N., Zuhrotun, A., Amalia, R., & Hadisaputri, Y. E. (2022). Pharmacological activities of soursop (*Annona muricata* Lin.). *Molecules*, 27(4), 1201.
- Nabilah, B. A. (2013). *Product Development of Soursop (Annona Muricata L) Ice Cream Mixed with Soy Milk* (Doctoral dissertation, University Malaysia Sabah).
- Neelwarne, B. (Ed.). (2012). *Red beet biotechnology: food and pharmaceutical applications*. Springer Science & Business Media.

- Nottingham, S. (2004). *Eat your genes: how genetically modified food is entering our diet*. Zed Books.
- Oborin, M. (2022). The Consumer Market of the Country: Current Trends. *Vestnik Volgogradskogo gosudarstvennogo universiteta. Ekonomika*, 24(4), 95-105.
<https://doi.org/10.15688/ek.jvolsu.2022.4.8>.
- Okudu, H., & Umahi, E. (2017). Nutrients, Physicochemical and Sensory Attributes of Jams Produced from Soursop and Pawpaw Pulp. *International Journal of Food Nutrition Research*. Retrieved from [DocsLib](#).
- Olabinjo, O. O. (2019). Evaluation of nutritional and phytochemical properties of dried soursop seeds. *Canadian Journal of Agriculture and Crops*, 5(1), 25-34.
- Olagunju, A. I., & Sandewa, O. E. (2018). Comparative Physicochemical Properties and Antioxidant Activity of Dietary Soursop Milkshake. *Beverages*, 4(2), 38. <https://doi.org/10.3390/beverages4020038>
- Onwezen, M. C., Bouwman, E. P., Reinders, M. J., & Dagevos, H. (2021). A systematic review on consumer acceptance of alternative proteins: Pulses, algae, insects, plant-based meat alternatives, and cultured meat. *Appetite*, 159, 105058.
- Ortuno, A. A., Baidez, P., Gomez, M. C., Arcas, I., Porrás, A. G., & Rio, J.A.D. (2006). Citrus paradise and Citrus sinensis flavonoids: Their influence in the defense mechanism against *Penicillium digitatum*. *Food Chemistry*, 98(2), 351-358.

- Orwa, C., Mutua, A., Kindt, R., Jamnadass, R., & Simons, A. (2009). Agroforestry Database: a tree reference and selection guide. Version 4. *Agroforestry Database: a tree reference and selection guide. Version 4.*
- Owen, K. (2018). All You Need To Know About The History Of Soursop Plantation — TKO Farms. *TKO Farms*.
<https://www.tkofarms.com/blog/2018/4/16/all-you-need-to-know-about-the-history-of-soursop-plantation>
- Parn, O. J., Bhat, R., Yeoh, T. K., & Al-Hassan, A. A. (2015). Sensory evaluation and consumer acceptance of beetroot-based products. *Food Bioscience*, 9, 20-27. doi:10.1016/j.fbio.2015.01.002.
- Perumpuli, B., Kaumal, M. N., Perumpuli, P., Fernando, G., Arandara, M., & Silva, S. (2018). Development of Low Sugar Vegetable Jam from Beetroot (*Beta vulgaris* L.): Studies on Physicochemical Sensory and Nutritional Properties Identification and characterization of acetic acid bacteria isolated from Sri Lanka View project Covid-19 response View . *International Journal of Theoretical & Applied Sciences*, August.
<https://www.researchgate.net/publication/327252914>
- Pinto, A. D. Q., Cordeiro, M. C. R., De Andrade, S. R. M., Ferreira, F. R., Filgueiras, H. D., Alves, R. E., & Kinpara, D. I. (2005). *Annona* species. *embrapa cerrados-livro científico (ALICE)*. Southampton: ICUC.
- Porter, M. E. (2007). *Competitive strategy: Techniques for analyzing industries and competitors*. Free Press.

- Rahman, M. A., Khan, M. R., & Begum, R. (2022). The role of sweeteners in the preservation and quality of beetroot jam. *Food Chemistry*, 371(5), 130-137. <https://doi.org/10.1016/j.foodchem.2022.130-137>
- Rahmani, A. H., Aly, S. M., Ali, H., Babiker, A. Y., & Srikar, S. (2014). Therapeutic effects of date fruits (*Phoenix dactylifera*) in the prevention of diseases via modulation of anti-inflammatory, anti-oxidant and anti-tumour activity. *International Journal of Clinical and Experimental Medicine*, 7(3), 483.
- Rajagopal, & Rajagopal. (2020). Development of consumer behavior. *Transgenerational Marketing: Evolution, Expansion, and Experience*, 163-194.
- Ramawat, K. G. (2010). *Desert Plants: Biology and Biotechnology*. Springer BerlinCY.
- Rao, E., R., Lalmuanpuia, C., Krishna, U., & Saloni, G. (2021). Naturally occurring non-nutritive sweeteners: A review. *International Journal of Applied Research*.
<https://doi.org/10.22271/ALLRESEARCH.2021.V7.I7A.8724>.
- Rd, C. S. M. (2023). Health benefits of dates. *Health*.
<https://www.health.com/nutrition/groceries/health-benefits-dates#:~:text=The%20antioxidants%2C%20minerals%2C%20and%20vitamins,or%20eat%20them%20as%20is.>
- Rdn, A. B. M. (2023, May 12). *Beetroot 101: nutrition Facts and health Benefits*. Healthline.
<https://www.healthline.com/nutrition/foods/beetroot>

- Romeiras, M. M., Vieira, A., Silva, D. N., Moura, M., Santos-Guerra, A., Batista, D., ... & Paulo, O. S. (2016). Evolutionary and biogeographic insights on the Macaronesian Beta-Patellifolia species (Amaranthaceae) from a time-scaled molecular phylogeny. *PLoS One*, *11*(3), e0152456.
- Sacramento, C. K. D., Faria, J. C., Cruz, F. L. D., Barretto, W. D. S., Gaspar, J. W., & Leite, J. B. V. (2003). Caracterização física e química de frutos de três tipos de gravioleira (*Annona muricata* L.). *Revista Brasileira de Fruticultura*, *25*, 329-331.
- Salmani, F., Norozi, E., Moodi, M., & Zeinali, T. (2020). Assessment of attitudes toward functional foods based on theory of planned behavior: Validation of a questionnaire. *Nutrition Journal*, *19*(1), 1–9. <https://doi.org/10.1186/S12937-020-00574-4/TABLES/5>
- Sánchez, C. F. B., Lopes, B. E., Teodoro, P. E., Garcia, A. D. P., Peixoto, L. D. A., Silva, L. A., & Bhering, L. L. (2018). Genetic diversity among soursop genotypes based on fruit production. *Bioscience Journal*, *34*(1), 122-128.
- Sandhya, P., & Priya, S. (2017). Formulation of beetroot cream cheese spread. *International Journal of Information Research and Review*, *4*(6), 3710–3712.
- Sani, I. (2015). Proximate analysis, phytochemical screening and antioxidant potential of ajwa date from medina, saudi arabia. *International Research Journal of Pharmaceutical and Bioscience* *2* (1): 12-17
- Santos, I. L., Rodrigues, A. M. da C., Amante, E. R., & Silva, L. H. M. da. (2023). Soursop (*Annona muricata*) Properties and Perspectives for

Integral Valorization. *Foods*, 12(7), 1448.

<https://doi.org/10.3390/foods12071448>

Sethi, V., & Sethi, S. (2006). *Processing of fruits and vegetables for value addition*. Indus Publishing.

Shashirekha, M. N., Mallikarjuna, S. E., & Rajarathnam, S. (2015). Status of bioactive compounds in foods, with focus on fruits and vegetables. *Critical Reviews in Food Science and Nutrition*, 55(10), 1324-1339.

Shiby, Y. K., & Tabassum, A. (2021). Sensory Evaluation Techniques and Consumer Perception Studies for Food Product Innovations. In *Advances in Processing Technology* (pp. 1-29). CRC Press.

Silayoi, P., & Speece, M. (2007). The importance of packaging attributes: a conjoint analysis approach. *European Journal of Marketing*, 41(11/12), 1495-1517.

Singh, J., & Kaur, A. (2020). Influence of Jaggery Addition on Sensory and Antioxidant Properties of Beetroot Jam. *International Journal of Food Science and Technology (IJFST)*, 55(2), 789-795.

<https://doi.org/10.1111/ijfs.14356>

Singh, R., Sharma, P., & Kaur, J. (2018). Stability and quality assessment of beetroot jam under different storage conditions. *International Journal of Food Science*, 53(12), 430-440.

<https://doi.org/10.1111/ijfs.2018.57.12.78>

Singh-Ackbarali, D., & Maharaj, R. (2014). Sensory evaluation as a tool in determining acceptability of innovative products developed by undergraduate students in food science and technology at the University

- of Trinidad and Tobago. *Journal of Curriculum and Teaching*, 3(1), 10-27.
- Smyth, S., & Heron, A. (2006). Diabetes and obesity: The twin epidemics. *Nat Med*. Published online.
- Sosef, M. S. M., Hong, L. T., & Prawirohatmodjo, S. (1998). *Plant resources of South-East Asia*. No. 5 (3): Timber trees: lesser-known timbers.
- Srivastava, S., & Bala, L. (2018). *Study on development and shelf life of beetroot storable products*. Sage Publication.
- Tađpinar, K., Öztürk, M., Altay, V., & Polat, H. (2019). Sugar Beet: An Overutilized Ancient Crop. In *Crop production technologies for sustainable use and conservation* (pp. 321-363). Apple Academic Press.
- Thompson, A. K. (2008). *Fruit and vegetables: harvesting, handling and storage*. John Wiley & Sons.
- Tnn. (2018, July 14). What is beetroot? Its health benefits, best ways of eating and interesting recipes. *Bombay Times*.
<https://recipes.timesofindia.com/articles/food-news/what-is-beetroot-its-health-benefits-best-ways-of-eating-and-interesting-recipes/articleshow/64649365.cms>
- Tripathi, P. C., Sankar, V., & Kumar, S. R. (2014). Sour Sop—An emerging fruit of future. *Central Hort. Exp. Sta., Chettalli, Kodagu, Karnataka. Tech. Bul*, 5(2014), 14.
- Tuorila, H., & Hartmann, C. (2020). Consumer responses to novel and unfamiliar foods. *Current Opinion in Food Science*, 33, 1-8.

- Upadhyay, R. K. (2023). High cholesterol disorders, myocardial infarction and its therapeutics. *World Journal of Cardiovascular Diseases*, 13(8), 433-469.
- Urala, N., & Lähteenmäki, L. (2007). Consumers' changing attitudes towards functional foods. *Food Qual Prefer*, 18(1), 1–12.
<https://doi.org/10.1016/j.foodqual.2005.06.007>
- Urziceanu, R. M., & Paşcalău, V. S. (2016). The purchase behavior of the consumer. *Agora International Journal of Economical Sciences*, 10, 41-44.
- Văduva, M. (2016). Consumption and the Consumer. *Economics and Applied Informatics*, 22, 101-106.
- Vassilev, S. V., Vassileva, C. G., Song, Y. C., Li, W. Y., & Feng, J. (2017). Ash contents and ash-forming elements of biomass and their significance for solid biofuel combustion. *Fuel*, 208, 377-409.
- Viera, G. H. F., Mourão, J. A., Ângelo, Â. M., Costa, R. A., & Vieira, R. H. S. D. F. (2010). Antibacterial effect (in vitro) of *Moringa oleifera* and *Annona muricata* against Gram positive and Gram negative bacteria. *Revista Do Instituto De Medicina Tropical De Sao Paulo*, 52(3), 129–132. <https://doi.org/10.1590/s0036-46652010000300003>
- Wagner, W. L., Herbst, D. R., & Lorence, D. H. (2017). Flora of the Hawaiian Islands website. *Flora of the Hawaiian Islands website*.
- Wang, S., Wang, J., Yang, F., Li, J., & Song, J. (2020). Determinants of consumers' remanufactured products purchase intentions: Evidence from China. *International Journal of Production Research*, 58, 2368 - 2383. <https://doi.org/10.1080/00207543.2019.1630767>.

- WebMD Editorial Contributors. (2020, September 24). *Health benefits of Soursop*. WebMD. <https://www.webmd.com/food-recipes/health-benefits-soursop>
- Wiczowski, W., Romaszko, E., Szawara-Nowak, D., & Piskula, M. K. (2018). The impact of the matrix of red beet products and interindividual variability on betacyanins bioavailability in humans. *Food Research International*, *108*, 530-538.
- Woodroof, J. (1986). History and Growth of Fruit *Processing*. , 1-24. https://doi.org/10.1007/978-94-011-7385-8_1.
- Worrell, D. B., Carrington, C. M. S., & Huber, D. J. (2004). Characterisation of fruit development and ripening in soursop and breadfruit. *Hortscience*, *25*(9), 1084d–11084. <https://doi.org/10.21273/hortsci.25.9.1084d>
- Wu, S., Jia, W., He, H., Yin, J., Xu, H., He, C., ... & Cheng, R. (2023). A new dietary fiber can enhance satiety and reduce postprandial blood glucose in healthy adults: A randomized cross-over trial. *Nutrients*, *15*(21), 4569.
- Younas, A., Naqvi, S. A., Khan, M. R., Shabbir, M. A., Jatoi, M. A., Anwar, F., & Aadil, R. M. (2020). Functional food and nutra-pharmaceutical perspectives of date (*Phoenix dactylifera* L.) fruit. *Journal of Food Biochemistry*, *44*(9), e13332.
- Zaid, A., & Arias-Jimenez, E. J. (2002). Date palm cultivation FAO plant and protection paper.
- Zhu, G. L., Mosyakin, S. L., & Clemants, S. E. (2003). Chenopodiaceae. *Flora of China*, *5*, 351-414.

Zhu, Z., Liu, R., Li, B., & Tian, S. (2013). Characterization of genes encoding key enzymes involved in sugar metabolism of apple fruit in controlled atmosphere storage. *Food Chemistry*, 141 (4), 3323-3328. <https://doi.org/10.1016/j.foodchem.2013.06.025>.



APPENDICES

APPENDIX A: SENSORY EVALUATION QUESTIONNAIRE

Sensory Evaluation of BeetSop Jam Spread produced from Beetroot and Soursop

Date.....

No.....

Sex.....

Age.....

Spread each of the coded spread samples on the bread provided and complete the questionnaire based on appearance, taste, texture, aroma and overall acceptability using the scale below. Put the appropriate code against each attribute.

QUESTIONNAIRE:

Please score each product from the scale of 1 to 5 by writing the appropriate number against each attribute.

- 1- Like very much
- 2- Like moderately
- 3- Neither like nor dislike
- 4- Dislike moderately
- 5- Dislike very much

Please wash your mouth with the water provided before and after analysing each sample.

Attributes					
Coded Sample	Appearance	Taste	Texture	Aroma	Over all Acceptability
BPJ					
BAS					
SWB					
BWS					

Comments:

.....

.....

.....

.....



THANK YOU FOR YOUR PARTICIPATION.

INFORMED CONSENT FORM

Consent forms for sensory evaluation of spread produced from beetroot and soursop.

I am investigating the sensory qualities of spread produced from beetroot and soursop using date as a healthier sweetener. This product will help increase the consumption of beetroot and soursop which is healthy and nutritious for people of all works of life and ages. Responding to the following questionnaire will take approximately 30 minutes of your time. The following are the list of ingredients in the spread: beetroot, soursop, date and lemon.

****should you be allergic to any of the above ingredient; please do not volunteer for this study***

If you agree to participate in this study please sign the consent form provided. Confidentiality and anonymity is assured. Your participation in this study is voluntary and do not hesitate to withdraw anytime you decide to. If you have any question regarding this study, please contact:

ELIZABETH OPOKU

0556521990

I have read/ someone have read and explained to me the information presented above and voluntarily agree to participate in this study.

.....

.....

Participant's signature/ thumbprint

Date

Name of participant

Date

Signature/thumbprint

Title: *Consumer acceptability and nutritional composition of beetroot and soursop (BeetSop) preserve.*

Principal Investigator: ELIZABETH OPOKU

Address: Elizabeth Opoku

Post office box 2007

Koforidua E/R



APPENDIX D: ETHICAL CLEARANCE

UNIVERSITY OF CAPE COAST

INSTITUTIONAL REVIEW BOARD SECRETARIAT

TEL: 0558093143 / 0508878309
E-MAIL: irb@ucc.edu.gh
OUR REF: IRB/C3/Vol.1/0484
YOUR REF:
OMB NO: 0990-0279
ORG #: IORG0011497

13TH NOVEMBER, 2023

Ms Elizabeth Opoku
Department of Vocational and Technical Education
University of Cape Coast

Dear Ms Opoku

ETHICAL CLEARANCE – ID (UCCIRB/CES/2023/95)

The University of Cape Coast Institutional Review Board (UCCIRB) has granted Provisional Approval for the implementation of your research **Nutritional Composition and Consumer Acceptability of Beetroot and Soursop (Beetsop) Spread using Dates as Sweetener**. This approval is valid from **13th November 2023** to **12th November 2024**. You may apply for an extension of ethical approval if the study lasts for more than 12 months.

Please note that any modification to the project must first receive renewal clearance from the UCCIRB before its implementation. You are required to submit a periodic review of the protocol to the Board and a final full review to the UCCIRB on completion of the research. The UCCIRB may observe or cause to be observed procedures and records of the research during and after implementation.

You are also required to report all serious adverse events related to this study to the UCCIRB within seven days verbally and fourteen days in writing.

Always quote the protocol identification number in all future correspondence with us about this protocol.

Yours faithful,

A handwritten signature in black ink, appearing to read 'Kofi F. Amuquandoh'.

Kofi F. Amuquandoh
Ag. Administrator

