NUTRITIONAL ATTRIBUTES AND CONSUMER ACCEPTABILITY OF YOGURT SWEETENED AND FLAVORED WITH SOURSOP PULP AND LIME JUICE

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ABSTRACT

Yogurt is one of the most widely consumed fermented dairy products due to its various nutritional benefits, especially its protein content and probiotic activity. One of the most commonly consumed yogurt types is flavored yogurt and fruit yogurt which involve use of a refined sugar and as a sweetener and yet over the recent decade, consumer preferences have been seen to shift from taste or flavor being the main drive to use of natural ingredients and additives such as flavorants, nutrient content and environmental impact as priorities. This research was focused on the use of soursop pulp as a natural sweetener in total replacement of refined sugar during yogurt production and also use of lime juice as a natural flavorant. Three batches were prepared and three treatments randomly assigned for each batch. To batch 1, soursop pulp containing 2% lime juice was added to the yogurt(T1), to batch 2, only soursop pulp was added to the yogurt (0% lime juice) which acted as the control and to the third batch, 3% lime juice was added to the yogurt. Chemical qualities of the yogurt such as fat, carbohydrate, protein, fibre and Vitamin C content of the soursop pulp- lime yogurt was determined and they were compared against the same nutritional attributes of conventional strawberry fruit yogurt. A one sample t test was carried out to compare the results. The results revealed that significant differences ($p<0.001$) in protein, fat, total carbohydrate, total fibre and vitamin C content between the soursop pulp-lime yogurt and strawberry fruit yogurt used for comparison. The soursop pulp-lime yogurt exhibited slightly higher protein, fat and fibre content. There was significant decrease in the carbohydrate content and increase in the Vitamin C content as well. Consumer acceptability testing was also carried out and the results revealed that colour scores were highest for 3% lime juice, aroma scores were highest for 2% lime juice and consistency scores highest in 3% lime juice. Mouthfeel scores decreased slightly with an increase in lime juice. The overall taste was rated highest for 2% lime juice.

DECLARATION

I, **KEMIGISHA FAITH ESTHER,** declare that this dissertation is a result of my independent work and has been compiled by myself. This dissertation is submitted in partial fulfilment of the requirements for the award of Bachelor of Food Science and Technology at the Ugandan Christian University and has never been submitted to any institution of learning.

Name; …….

Signature; …….

Date; ……..

KEMIGISHA FAITH ESTHER J22B52/005

APPROVAL

This is to certify that this research dissertation has been submitted for examination with my approval as the academic supervisor as a requirement for the award of a Bachelor's Degree in Food Science and Technology.

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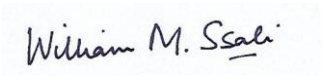
SIGNATURE: 

DEDICATION

I dedicate this report to my supportive parents, project supervisor, Head of Department of Food and Nutritional Sciences, and my fellow student colleagues who stood by me during this research with endless motivation and support. This ensured that I was guided in the right way to go about the research and helped ensure that I remained persistent until the successful completion of this research. I shall forever be grateful, and I pray that God Almighty will richly bless you in your lives.

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UIRI- Uganda Industrial Research Institute

SD- Standard Deviation

AOAC- Association of Official Analytical Chemists

ISO- International Standards Organization

MC- Moisture Content

NAOH- Sodium hydroxide

CHAPTER ONE

1. INTRODUCTION

1.1 Background of study

Fermented drinks and food, particularly yogurt, have been largely consumed over centuries due to their flavor and nutritional benefits, such as high protein content, treatment of lactose intolerance. They are rich in minerals such as calcium, which is essential in bone structure, and potassium (Katia Sivieri et al, 2017)

Yogurt is one of the most popular dairy products globally, with major consumers in countries such as France, the United States of America, China, the Netherlands, Turkey, and India. China, for example, has an average per capita consumption of about 5kg per consumer annually. The yogurt market is particularly big in North America and Europe. According to World Integrated Trade Solution (WITS) data for 2023, Germany led exports with about $780.5 million, followed by the European Union collectively at $523.4 million, Greece at $351.4 million, France at $348.7 million, and Spain at $170.6 million (World Integrated Trade Solution, 2023).

Yogurt is made using specific bacteria known as yogurt cultures, which are primarily *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. Strains such as *Lactobacillus delbrueckii* and *Streptococcus salivarius* can be added to improve the probiotic content of the yogurt. Probiotics are harmless, live and active microorganisms ingested to alter the gastrointestinal flora for health benefits. These ferment lactose to lactic acid, giving yogurt its texture and tang. Yogurt is considered a probiotic product offering several health benefits, such as improved lactose digestion, but also easy digestion in general since it's easier for the body to absorb its nutrients, offers strengthening of the immune system, and reduces risks of type 2 diabetes and gut disorders (Nahed L Zaki et al, 2021). Yogurt is rich in high-quality proteins, carbohydrates, calcium, phosphorus, potassium, and vitamins B6 and B12. Various yogurt types include plain, Greek, frozen, fruit, and flavored-sweetened yogurt. However, over the past decade, studies have shown that consumer preferences for food products have shifted from taste and flavor as the main drive towards nutrient content, natural additives and sweeteners, and

environmentally friendly food products or ingredients being prioritized (Jovana Dzoljic et al., 2018). This trend shows that consumers have become more health conscious. Soursop fruit, *Annona muricata*, which is known for its sweetness (Makebe Calister Wingang, 2021), and lime (*Citrus aurantifolia*), valued for its tanginess, are potential natural alternatives for sweetening and flavoring yogurt. Furthermore, soursop has high nutritional content while lime, is also a rich source of vitamin C and other antioxidants that are essential in the elimination of free radicals from the human body (Kamelia Ramadaini et al, 2020). Both fruits are currently underutilized in the country due to a lack of knowledge of their nutritional and economic benefits.

Previous studies have shown that soursop puree or pulp, when added to yogurt, improved on the functional, sensory, and nutritional properties of yogurt (Senadeera et al, 2018) and also contributed to an increase in vitamin C content of the yogurt (Saputrayadi et al,2021). Further studies have also shown that the soursop puree or pulp was added to yogurt during its manufacture, mainly to improve the flavor of the yogurt. Soursop pulp was also added in partial substitution of refined sugars such as sucrose. (Mayowa Saheed Sanusi et al, 2023). Lime has been added to fruit juices in previous studies to improve the microbial quality of the fruit juices to increase their shelf life due to its anti-microbial and anti-oxidant properties. (Micheal Okpara, 2013). However, there is limited information on the use of soursop pulp as a sweetener in full substitution of refined sugar during yogurt manufacture, and no substantial studies have been carried out on the use of lime juice as a flavorant in yogurt. There is also a need to further explore the interactive effect of lime juice and soursop pulp on the nutrient composition and consumer acceptability of yogurt.

The above information will highlight the potential of soursop pulp as a natural sweetener and lime juice as a natural and unique flavorant in yogurt, and therefore contribute to the development of healthier dairy products that align with the changing consumer preferences. The findings of this research will also provide valuable insights for food manufacturers seeking natural alternatives to refined sugars and innovative flavor profiles.

1.2 Problem statement

The global shift in consumer preferences has posed a challenge to the acceptability of food products on the market by emphasizing a demand for natural ingredients, improved nutrition profiles, and reduced reliance on refined sugars and synthetic additives. Soursop fruit (*Annona muricata*), a tropical fruit known for its natural sweetness and rich nutrient content, offers potential as a substitute for refined sugar in yogurt production. However, its complete substitution for refined sugar remains underexplored, particularly regarding its ability to maintain sweetness levels while providing additional health benefits without compromising the fermentation process or sensory attributes of yogurt.

Similarly, lime juice, a natural flavorant with a good consumer appeal due its anti-bacterial, anti-oxidant and tangy properties, poses challenges in yogurt manufacturing due to its high acidic nature which risks curdling and formation of a bitter taste that affect product consistency and taste. Consequently, the feasibility of its use as a flavorant in yogurt remains unknown.

1.3 Purpose of the study

This research aims to address these gaps by determining the feasibility of using soursop as a full replacement for refined sugar in yogurt production and assessing lime juice as a natural flavorant without compromising yogurt texture, stability, and taste. This study seeks to develop innovative yogurt formulations that cater for health-conscious consumers, increasing utilization of soursop fruit and lime in the food and beverage industry through yogurt production; while ensuring maintenance of sensory attributes and product integrity during storage.

1.4 Objectives of the study

1.4.1 Main objective

To produce a sugar-free yogurt by fully substituting refined sugar with soursop pulp as a natural sweetener and incorporating lime juice as a natural flavorant, while assessing their combined impact on the nutritional, sensory, and physicochemical properties of the yogurt.

1.4.2 Specific objectives

1. To determine the vitamin C, protein, carbohydrate, fat, and fibre content of soursop pulp-lime yogurt and compare it with that of conventional fruit yogurt.

2. To determine the consumer acceptability of soursop pulp yogurt and soursop pulp-lime yogurt.

1.5 Hypothesis

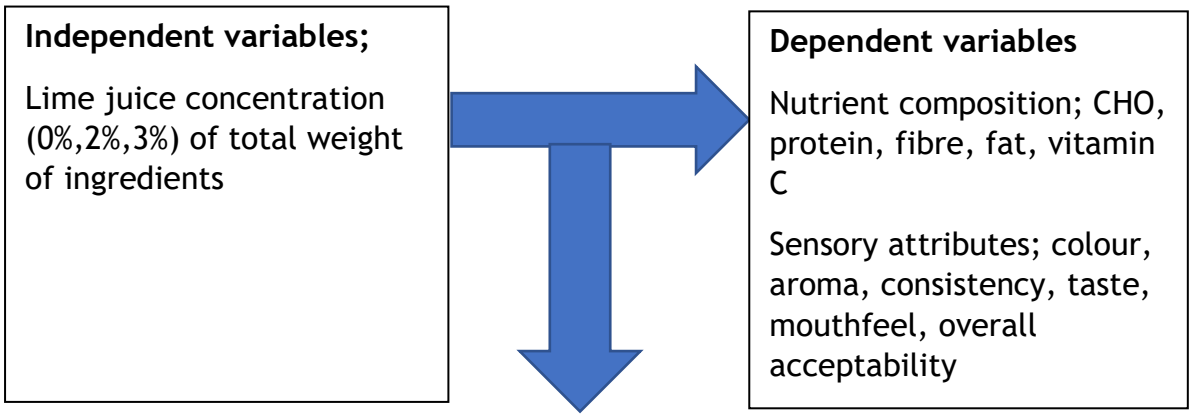
1. There is no difference in the vitamin C, protein, carbohydrate, fat and fibre content of soursop pulp-lime yogurt and that of conventional fruit yogurt.

2. There is no difference in the consumer acceptability of soursop pulp yogurt and soursop pulp-lime yogurt.

1.6 Significance of Study

This research was of great benefit to the food industry through creation of a functional yogurt that addresses consumer preferences and demand for natural and nutritive food options. The use of soursop pulp and lime juice as natural substitutes for refined sugar and artificial flavourings provided yogurt and non-sweetened yogurt consumers due to health concerns a healthier alternative which was sugar-free yogurt of similar taste as that of sweetened yogurt but with a unique flavor profile. Simultaneously, this study paved way for increased utilization of soursop and lime fruits fostering market growth for local producers in Uganda therefore increasing on income sources and diversity in agricultural communities.

1.7 Conceptual framework



Control variables
Fermentation time, pasteurisation temperature, maxigel, storage temperature

1.8 Scope of the study

This research covered the following areas; experimental production of sweetened sugar-free yogurt, utilizing soursop pulp as a natural sweetener and lime juice as a natural flavorant, determination of recipes involving varying quantities of lime juice that did not affect the fermentation process but still achieved the desired consistency and stability of the yogurt. The first key component of this research was the determination of vitamin C, protein, carbohydrate, fat and fibre content of the produced soursop-lime yogurt. This was followed by comparing it with the composition of the same nutrient attributes of conventional fruit yogurt. The purpose of this exercise was to demonstrate nutritional advantages or otherwise, since conventional fruit yogurt has almost similar nutritional properties like those of soursop pulp-lime yogurt especially in aspects of vitamin C and fibre as opposed to ordinary sweetened yogurt. Furthermore, the study assessed the consumer acceptability of soursop pulp yogurt without lime juice and soursop pulp yogurt to which different concentrations of lime had been added through sensory evaluation using an untrained panel to gauge overall yogurt preference of the consumers.

1.9 Limitations of the study

The use of a fixed 1:1 replacement ratio of the soursop for sugar may not identify the optimal concentration for sweetness, flavor and overall quality of the yogurt. Varying concentrations could potentially yield better sensory and nutritional results. The comprehensive nutrient analysis will be carried on only one soursop pulp-lime yogurt treatment which leaves gaps in drawing definitive conclusions on the nutrient content of the other treatments that will be made. The absence of a shelf-life study makes it difficult to assess the long-term stability of the sensory attributes and microbial quality and therefore safety of the soursop pulp-lime yogurt. Finally, the

consumer acceptability results obtained in Uganda may not be directly applicable to other regions with differing taste preferences and cultural backgrounds.

1.10 Organization of the study

The study is organized in chapters. Chapter one has the introduction which is made up of the background of the study, statement of problem, objectives of study, significance of study, scope of study, limitation of study and organization of study. Chapter two contains the review of existing literature in relation to the topic of study. Chapter three contains the methodology adopted for the study, chapter four presents the results, their interpretation and discussion and last but not least chapter five which is concerned with the summary of the study findings, conclusions and recommendations.

CHAPTER TWO

2.0 Literature Review

2.1 Overview of yogurt

The word *fermentation* came from a Latin word, *fevere,* which was later explained by Louis Pasteur as "life without air". It is scientifically defined as a metabolic process that produces energy from organic compounds with or without the involvement of exogenous agents such as microbial enzymes or microorganisms.

For a very long time, fermented drinks and foods contributed greatly to the human diet in terms of their nutritional health benefits, and Yogurt has emerged as one of the most consumed dairy fermented product on the market today (Andrzej Blazejczyk,2023). It has one of the fastest growing markets with France, Turkey, Netherlands, United States and China being some of the world's biggest consumers (C. Chandan, 2024, A. Shunekeyeva, M. Alimardanova et al., 2021) The largest consumer is China with an average consumption of about 5kgs per person per year. Geographically, North America is the major contributor to the yogurt market in terms of value followed by Europe and this has been due to introduction of new flavors that offer low fat benefits. In the Asian Pacific region, China dominates the market followed by India with Japan showing continuous steady growth in the past years.

The total export value of yogurt around the world in 2015 was more than 2 million US dollars with about 1.5 million tons of yogurt being exported around the world. Germany has been the leading exporter of yogurt for many years with a trade value of more than 500,000 US dollars and 500,000 tons in 2015 which accounts for more than 30% of the yogurt traded globally. (IDF, 2016). The bacteria used to make yogurt are known as yogurt cultures and these cultures include ***Lactobacillus delbrueckii subspecies bulgaricus and Streptococcus salivarius subspecies thermophilus according to the CODEX standards (CODEX STAN 243-2003)***. In addition, others like ***Lactobacilli*** **and** ***Bifidobacteria*** are also sometimes added during or after culturing the yogurt. Fermentation of lactose by these bacteria produces lactic acid, which acts on milk protein to give yogurt its texture and characteristic tang. It is a probiotic product since it contains live active microorganisms which upon ingestion

in sufficient number exert health benefits beyond the inherent basic nutrition (CODEX STAN 243-2003). This benefit has increased the consumption of yogurt.

Figure 1: A picture of produced yogurt

2.2 Nutritional benefits of yogurt

Yogurt supplies good quality proteins, which are important in the synthesis of organic molecules in the body that in order to maintain catabolic and anabolic processes in the body. It is also an excellent source of carbohydrates, which are a source of energy to the body. It is also important in the prevention of type 2 diabetes due to its probiotic content, which improves insulin sensitivity (Koichiro Sumi et al).

Yogurt is also crucial in weight management, for it creates satiety, which reduces overeating. Probiotics in yogurt enhance gut health by improving digestion and alleviating conditions like irritable bowel syndrome and lactose intolerance by breaking down the lactose. Yogurt helps to reduce cardio metabolic diseases by lowering serum cholesterol levels. It is also rich in calcium, vitamin D, which support bone density and reduce the risk of osteoporosis (Christopher J Cifelli et al, 2020). The probiotics in the yogurt have immune-modulatory effects that boost the body's defense mechanism. Yogurt also controls infections by inhibiting the growth of pathogenic organisms. Yogurt's nutrients contribute to healthier skin by improving hydration and reducing inflammation and bloating (Julie M Glanville et al, 2015).

The popular varieties of yogurt include;

Plain yogurt which is traditional yogurt without added flavors or sweeteners for enhanced taste. It serves as a versatile base for dishes or snacks.

Fruit or flavored yogurt which contains added fruit, flavors or sweeteners for enhanced taste. It is popular among children and those seeking a sweeter option. This is one of most widely consumed type of yogurt.

Greek yogurt (strained yogurt) which is a thick and creamy yogurt due to straining to remove whey. It has a higher protein content compared to normal yogurt.

Frozen yogurt which is a dessert alternative to ice cream, offering lower fat content while retaining probiotics.

Soy yogurt, which is made from soy milk instead of dairy, is suitable for vegans or individuals with lactose intolerance.

Yogurt beverages with often drinkable combined with fruit juices or other flavors for convenience and refreshment.

Probiotic yogurt, which contains live bacterial cultures specifically added for their health benefits, such as improving gut microbiota balance. (Katia Sivieri et al, 2017)

2.3 Soursop fruit description

2.3.1 Classification of soursop fruit

Soursop belongs to the Annonaceae family which is a family in the plant kingdom with 50 genera and three of those are edible fruits (*Annona, Rollinia, Asimina*) with the first two being of commercial importance. It generally consists of 390 species in the tropical and subtropical areas world-wide (Pinto et al, 2017). A. Muricata is classified as shown below;

Kingdom; Plantae

Division; Magnoliophyta (Angiosperms)

Class; Magnolids

Order; Magnoliales

Family; Annonaceae

Genus; Annona

Species; muricata

The soursop fruit is a fused-together berry that is dark green in colour with a spiky or spiney surface (Patel and Patel, 2016) and associated flower parts. It is a heart or oval-shaped fruit with about 5-200 seeds. (Blancke, 2016). The average weight of a healthy soursop fruit is about 4kg, and it has a creamy coloured granular interior with an edible, fibrous and juicy fleshy pulp which can easily be peeled away from its core. The soursop fruits can be categorized into: acid, subacid, and sweet, or can be grouped according to how their flesh is, i.e., wet, soft, stiff, and extremely dry (Matsuda,2017)

Soursop fruit, botanically known as *Annona muricata,* locally known as "Ekitaferi" in Uganda, is a delicious fruit widely grown in the tropics and subtropical regions of the world, including South America, Africa, and Asia, with the largest being Mexico.

Figure 2 A picture of soursop fruit

2.4 Chemical composition of soursop fruit

The soursop fruit is made up of 20% skin, 67.5% edible pulp, 4% core, and 8.5% seeds by weight. (Uchegbu et al, 2018). The white edible pulp contains 1% protein, 18% carbohydrate, 3.43% titratable acidity, 80-81% water, 24.5% non-reducing sugar, and vitamins B1, B2, and C. Furthermore, soursop is made up o 53.1-61.3 calories, 82.8g moisture, 1 g protein, 0.97g of fat, 60 g of ash, 10.3mg of calcium, 0.79g of fibre which makes up 0.78-0.95% of the pulp (Gavamukyala et al, 2017), 0.64mg of iron, 0.11mg thiamine, 29.6mg of vitamin C, 11mg tryptophan, methionine (7mg), 60g lysine, sugars account between 67.2-69.9% of the total solids. (Princess Hannah, 2023). The fructose, D-glucose, and sucrose percentages in the soursop pulp were

1.80,2.27, and 6.57%, making the total sugar content 10.48%. It also contains 12% sugar (Siqueira et al., 2015) with pectin making up the majority of the alcohol-insoluble solids, which are 4.0% by dry weight between pre-climacteric and climacteric stages and 0.91% by fresh weight from pre-climacteric stages. The pH of the pulp is 4.56, soluble solids concentration is 151^0 for the pulp. (Princess Hannah, 2023)

2.5 Post-harvest challenges and proper handling of soursop.

Preliminary analyses have indicated a substantial loss of 75.8% for tropical fruits like soursop. This loss is accelerated by poor field farmer practices and growers' lack of knowledge and understanding of factors affecting fruit quality. In Uganda, soursop has low production due to its low demand and high pre-harvest and post-harvest losses caused by the fruit borer, leading to 30% loss and 54% total pulp yield (Kankwatsa et al., 2017). This has led to scattered production by only willing individual farmers in the country. Soursop fruits are usually harvested when they are fully developed and still a bit firm and yellow-green (physiological maturity) (Badrie & Schauss, 2010) or else they will fall and be crushed if allowed to deteriorate on the tree. Ripe soursop fruits are highly delicate and prone to bruising which shortens their post-harvest life and that is why ripening at room temperature is recommended as young fruits do not fully develop aroma and flavor when ripened off the tree. Soursop fruits are highly sensitive to cold temperatures with chilling injuries causing skin darkening, inability to ripen, pulp discoloration, poor flavor and aroma and increased rot (de Lima and Alves, 2011).

To prevent spoilage and reduce deterioration of soursop fruit, the soursop fruit is pulp and the pulp pasteurized at 79^0C for 69 seconds to preserve nutrients, inactivate spoilage enzymes and reduce microbial load and is then refrigerated at temperatures between 4^0C (Jerry Ampofo-Asiama et al., 2018) to increase its shelf life from 5 days to 12 weeks. One of the other significant challenges faced with soursop fruit is that it has a short harvest season and so cultivators that have various maturity durations have been created in effort to balance the market supply (Badrie & Schauss, 2010) and has low production majorly due to its very low demand and high pre-harvest and post-harvest losses due to its perishability. It has a whitish

edible pulp that contains water, titratable acidity, carbohydrate, protein and non-reducing sugar of 80,3.43,18,1 and 24.5% respectively. (Badrie & Schauss 2010). Soursop fruit currently is mainly consumed as a fruit, juice or packed purees worldwide. Previous research in the last decade has shown that soursop fruit is rich in flavours especially in sweetening flavours i.e., rich in sugars, has a high nutritional profile i.e., contains vitamins, minerals, proteins, flavonoids, phenolic compounds with antidiabetic, antihypertensive, anticarcinogenic, antiobesity, antihypercholesterolemic, hypoglycemic and antibacterial properties. In addition, the pulp is rich in soluble fibres especially hydrolysed pectin (pectin oligosaccharides that are prebiotics and therefore are a source of food to probiotics in the gut especially the colon and maintain its health. (Mbaeyi-Nwaoha, Ekere K.S) It also has a high protein content and has been used in countries like Nigeria and Benin to treat protein deficiencies. (Rene G Degnon et al). Previous studies have shown that soursop puree or pulp, when added to yogurt, improved the functional, sensory, and nutritional properties of yogurt (Senadeera et al, 2018) and also contributed to an increase in vitamin C content of the yogurt (Saputrayadi et al,2021). Further studies have also shown that the soursop puree or pulp was added to yogurt during its manufacture, mainly to improve the flavor of the yogurt in addition to refined sugar such as sucrose or in partial substitution of refined sugars with the soursop pulp. (Mayowa Saheed Sanusi et al, 2023).

2.6 Overview of lime fruit

Lime is a fruit botanically known as *Citrus aurantifolia* and locally known as “Enimu” is a citrus fruit known for its tangy-bitter taste, which is a common attribute of the citrus family of fruits. It is also known as orange pecel. Lime trees can reach 3-6 meters high, are branched and thorny with small oval leaves that have a winged petiole. The axillary leaves are where an inflorescence emerges to give small white fragrant flowers. The fruit is ovate or round-shaped and it has a green-yellow colour with thin skin that is rich in essential oils. The inside flesh of the fruit is greenish white and is rich in vitamin C, with many small and polyembryonic. They grow well in alkaline soils; places exposed to direct sunlight. Propagation of the fruit is by seed or grafting. The fruit is used to make drinks, cough medicine, and food flavoring. (Zikra Azizal., 2020) It is rich in phytochemical compounds such as alkaloids,

flavonoids (apigenin, rutin, quercetin, kaempferol, hesperidin), triterpenoids, saponins, tannins, phenolics, and vitamin C. (Kamelia Ramadaini et al., 2020)

Figure 3 A picture of lime fruit

2.7 Nutritional benefits of lime fruit

Lime's health benefits are mainly due to its phytochemical compounds. These health benefits include: (Kamelia Ramadaini et al., 2020)

Lime has anticarcinogenic effects where it stops the mobility of cancer cells, inhibits metastasis and angiogenesis, and induces tumor suppressor genes and apoptosis.

Lime peel extract has been used to help heal traumatic ulcers due to its anti-inflammatory properties and also inhibits bacterial growth and therefore is commonly used as a preservative.

Lime peel extract can help heal traumatic ulcers due to its anti-inflammatory properties.

Lime also aids in digestion due its acidity that provides an ideal environment for the action of stomach enzymes like pepsin, gastric amylase and lipase. (W. Abobatta et al, 2019).

The tangy taste from lime is important to balance the sweetness of the yogurt creating a uniform and balance flavor. (Rati Jani et al, 2024).

2.8 Changes in consumer preferences for food products

The factors driving consumer acceptability of food products are undergoing significant changes. Historically, taste and flavor were primary considerations, but recent trends indicate a shift towards nutritional benefits, the use of natural additives and natural sweeteners, particularly moving away from refined sugar. Consumers increasingly prefer products with fewer synthetic chemicals and more

natural ingredients such as stevia, which is a natural, intense sweetener used in various food categories like snacks and beverages (Jovana Dzoljic et al., 2018).

This shift is driven by health concerns such as obesity and chronic diseases linked to high sugar intake (N. Caglarirmak et al., 2021). Additionally, innovations in food technology like the development of functional gummy candies with natural sweeteners and antioxidants reflect this consumer preference for healthier options (Mohammad Tarahi et al.,2024). The dairy industry also sees a move towards clean label products, emphasizing natural ingredients over synthetic additives (Ume Roobab et al., 2021)

CHAPTER THREE

3.0 METHODOLOGY

3.1 MATERIALS AND METHODS

3.1 Introduction

This chapter contains materials, the method of carrying out the research, analysis of variables in the research, and what was used to interpret the results of the research.

3.2 Study location

The product preparation and sensory evaluation were carried out in the Food Science and Technology laboratory at Uganda Christian University, Mukono while the proximate analysis was carried out at Uganda Industrial Research Institute in Nakawa, Kampala, Uganda.

3.3 Sources of Information

Primary Data: this was derived from laboratory measurements of vitamin C, fat, carbohydrates, protein and fibre content and sensory evaluations from untrained habitual yoghurt consuming panelists for consumer acceptability.

Secondary Data: this included all material that informed the standard procedures of the analyses, the measurements to be used, procedures for carrying out the consumer acceptability test and explanations of the results obtained. This included literature on standard procedure on yogurt manufacture, laboratory testing manuals and articles on properties and effects of both soursop and lime on the sensory properties of different products.

3.4 Population and Sampling Techniques

The population of study consisted of three yoghurt batches prepared with 2% lime juice, 0%lime juice and 3% lime juice respectively. Conventional strawberry fruit yogurt was used for the comparative analysis because fruit yogurt in comparison to other types of yogurts has similar nutritional properties as those of soursop pulp-lime yogurt especially vitamin C and fibre in particular (since it contains fruits), which are absent in other yogurt types. Soursop pulp yogurt containing 3% lime juice was used for comparative analysis with conventional fruit yogurt since it had the highest amount of lime juice. The population of interest for consumer acceptability tests consisted of a panel of untrained habitual yoghurt consumers. 41 samples from each yogurt batch were randomly obtained from yogurt batches for consumer

acceptability because according to written literature, a range of 30-50 panelists is required if sensory evaluation for consumer acceptability is being carried out using an untrained panel and no replication will be required since preference tests will be carried out.

3.5 Measurement levels

Nominal; hedonic scale (1-9) representing the level of like and dislike (extremely dislike to extremely like)

Percentage of total weight; lime juice concentration, soursop pulp

Macro nutrients (fat, protein, carbohydrates, fibre); g

Micro nutrients (Vitamin C); mg

3.6 Materials and source

The materials for the research included ingredients for making the yogurt, such as Maxigel, ripened soursop fruits, fresh lime, UHT milk, and yogurt culture. Additional materials included table spoons, a stirrer (stainless steel), saucepans and a food temperature digital thermometer. The fresh lime was sourced from Sombe market, Mukono and the soursop fruit from Nakasero market, Kampala, and Sombe market, Mukono in Uganda.

3.7 Yogurt preparation

Six litres of milk were used to make 3 batches of the yogurt where each batch was made from 2 litres of milk. For each batch, the milk was pasteurized at a temperature of 80^0C for 5 minutes with constant stirring. The milk was left to cool to a temperature of 43-45^0C in a water bath. 5g of maxigel were first dissolved in a small amount of milk and added to the rest of the milk and the mixture stirred for even mixing. 10g of the yogurt culture were mixed a 3 table spoons of milk and then inoculated into the milk. The yogurt was left to ferment for a period of 8 hours where it reached until it reached a pH of 4.6.(Mbaeyi-Nwaoha et al, 2014)

3.8 Pulp extraction process

The soursop fruits were bought abit stiff and left to ripen fully for 2 days at room temperature on a shelf because ripening in the refrigerator would cause rotting due to chilling injuries and ripening allows full development of the flavor and aroma characteristics (Rene G Degnon et al, 2013). After ripening, the soft soursop fruit

was washed using running tap water and rinsed with warm water to further soften the skin. Gloves were worn and the fruit skin was gently peeled and separated from the white fleshy pulp. The seeds were then separated from the fleshy pulp and the pulp was blended for 20 minutes in a series of 5 minutes to prevent the blender from overheating. The smooth blend was then transferred to a saucepan where it was pasteurised at a temperature of 75^0C for 5 minutes in order to inactivate the spoilage enzymes, kill microorganisms but also maintain the nutrient composition of the soursop pulp since higher temperatures lead to reduction in the antioxidant and titratable acidity of the soursop pulp (Mbaeyi-Nwaoha et al, 2014). The pulp was left to cool in an airtight container until room temperature. 272g were measured off to be added to each batch.

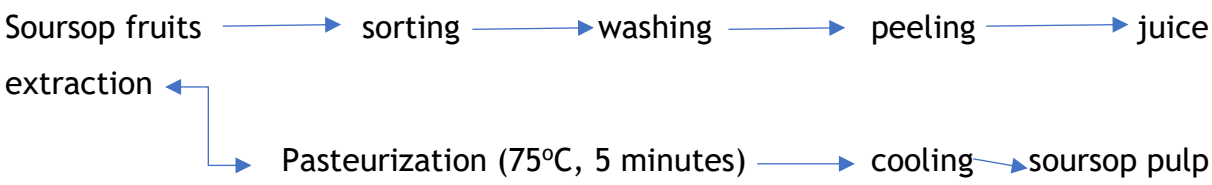


Figure 4; A flow chart showing juice extraction process

3.9 Lime juice extraction

The limes were washed in running water and scrubbed gently with a soft food brush and rinsed water containing 2% hypochloric acid to sanitize the fruits. The fruits were then dried and cut with a knife transversely for easy squeezing out of the juice. The juice was squeezed out through a thin mesh sieve to separate the juice from the seeds and any fruit flesh that may have come off the peel. 2% and 3% of the total weight of the milk mixture was measured and added to the soursop pulp of the batches where 2% and 3% lime were the treatments in its last minute of pasteurization and mixed with the pulp before it was removed off the heat source to be cooled.

3.10 Adding the soursop pulp mixture

To the first batch of yogurt, a mixture of 272g of soursop pulp and 2% lime juice were added, and the batch was labelled “Sample 1; 2% lime juice. To the second batch, only soursop pulp was added to the yogurt and the batch was labelled “Sample 2; 0% lime juice”. To the third batch, a mixture of soursop pulp and 3% lime

juice were added to the yogurt and the batch was labelled “Sample 3; 3% lime juice”. The yogurt and the soursop pulps were evenly mixed for a smooth consistency. The different yogurt batches were then stored at 4^0C and this was one according to the method by Naheed L. Zaki et al, 2021.

3.11 Experimental Design

In my study, I used a Completely Randomized Design (CRD) since I was varying only one factor (Abdullah et al, 2020) and my treatments consisted of three levels of lime juice concentration %(control), 2% and 3%. Three batches of yogurt were divided into three experimental units, one for each treatment level and were randomly assigned to the three treatments (0%,2%, and 3% lime juice concentrations) without replication. This ensured that any differences observed between batches were due to the treatments rather than other factors i.e., each batch received was exposed to either 0%,2% or 3% lime juice concentration. (citation). The independent variable in this study was the lime juice concentration and the dependent variables were physicochemical parameters such as protein, fat, vitamin C, carbohydrate and fat content. The other dependent variables were sensory attributes such as taste, colour, consistency, overall taste, aroma, overall acceptability, mouthfeel, tangy taste.

Table 3.1: Different treatments of soursop pulp-lime yogurt

Treatments	Sample number
0% lime juice	2
2% lime juice	1
3% lime juice	3

3.12 Data Collection and Protocol

3.12.1 Determination of chemical properties of soursop pulp- lime yogurt

The analysis was carried out at the Uganda Industrial Research Institute in Nakawa, Uganda, in triplicate using the methods below.

3.12.2 Determination of ash content in Yogurts

Equipment and materials(specified);

- Muffle furnace
- Desiccator
- Crucibles

Apparatus preparation

The ceramic crucibles were cleaned using hydrochloric acid 1:1 solution, rinsed with distilled water and dried in a muffle furnace at 550^{o}C for one hour. The muffle furnace was turned off and left to cool to 250^{o}C. Tongs were then used to transfer the crucibles to the desiccator and allowed to cool prior weighing. After 30 minutes, the crucibles were removed and weighed and the readings taken (UIRI Analytical Laboratories Quality Manual,2024)

Procedure

10g of the sample were weighed into a tarred crucible which was placed in a cool muffle furnace because the markings would be removed due to high temperatures in the furnace. The muffle furnace was ignited for 4-6 hours, turned off after and cooled to 250^{o}C before the samples were removed. The sample was checked to ensure that it was completely white with no black spots. The sample was relabeled and transferred to the desiccator using tongs and covered to cool. After 30 minutes, it was weighed and the readings taken.

Calculation

% Ash = G2-G1/W

Where, G2= Weight of crucible and sample after ashing

G1=Tare weight of crucible

W= Original sample weight

Quality control

A control sample was analyzed during each analysis and three replicates were run for each sample analyzed.

3.12.4 Determination of Vitamin C Content

Preparation of reagents (UIRI Analytical Laboratories Quality Manual,2024)

1.Starch Indicator solution

0.50g of soluble starch were weighed, added to 50 near boiling distilled water and mixed well before being cooled.

2.Iodine solution

5.00g of potassium iodide (KI) and 0.268g potassium iodate (KIO_3) in 200ml distilled water were dissolved and 30ml of sulphuric acid added. The solution was poured into a 500ml graduated cylinder and diluted to 500ml with distilled water. The solution was mixed and transferred to a 600ml beaker.

3.Vitamin C standard solution

0.250g of ascorbic acid were dissolved in 100ml distilled water and diluted up to 250ml in volumetric flask.

Standardizing solutions

25.00ml of vitamin C standard solution were added to a 125ml Erlenmeyer flask and 10 drops of 1% starch solution added. A burette was rinsed with a small volume of the iodine solution and filled. The initial volume was recorded. The solution was titrated until the end point was reached (a blue color that persisted after 20 seconds). The final volume of the iodide solution was recorded and the titration repeated at least twice.

Vitamin C titration

25ml of the sample were added to a 125ml Erlenmeyer flask and the sample was titrated exactly the same way as the standard and the initial and final recordings were taken.

Calculations

Moles of vitamin C= Moles of iodine X stoichiometric ratio

Mass in mg= number of moles X molar mass X 1000

3.12.5 Determination of fat content

The fat content of a sample was determined using the Soxhlet extraction method. A 50 g sample, remaining after moisture determination, was weighed and placed in a thimble. The thimble was then positioned in a Soxhlet extractor, and 300 mL of petroleum ether was added until some of it overflowed into the flask. The flask was heated on a water bath for approximately 8 hours to ensure complete extraction of the oil from the sample. After extraction, the oil dissolved in the solvent was separated by distillation, and any remaining solvent traces were removed by placing the contents in an oven at 100°C for 30 minutes until a constant weight was achieved. The fat content of the sample was calculated using the formula (Than Than Cho et al,202):

$$\text{Fat (\%)} = \frac{\text{Weight of fat (g)}}{\text{Weight of sample (g)}} \times 100$$

3.12.6 Determination of Protein Content by Kjeldahl Method

Equipment and materials

- 40% NaOH
- Digesting unit
- Kjeldahl distillation unit
- Boric acid
- Sulphuric acid

Procedure

An accurately weighed sample (ca 1.00 g) was placed in the Kjeldahl digestion tube as described in the (UIRI Analytical Laboratories,2024). Kjeldahl catalyst, anhydrous copper sulphate (8 g), pure sulphuric acid (50 mL), and some pieces of pumice stone were added to the Kjeldahl digestion tube. Then it was shaken until the contents were well mixed. The digestion tube with the sample was placed into the Bloc-digest with the fume removed, operating. The digestion was done at a temperature of

150°C for 15 min, 300°C for 15 min, and 400°C for 1 hour. At the end of the process, the green colour liquid was obtained. It was allowed to cool and transferred into the conical flask. Distilled water (100 mL) was carefully added to the flask with frequent shaking. The Kjeldahl distillation apparatus was set up, taking care that the tip of the condenser extended well below the surface of the standard sulphuric acid solution (50 mL) in the receiver. The digested solution was poured into the distillation flask, and then 100 mL of 40 % sodium hydroxide solution was added to it through the dropping funnel to make the mixture strongly alkaline. The evolved ammonia was distilled off and passed into a receiver containing sulfuric acid. The distillate, with respect to excess sulfuric acid, was then titrated with a standard sodium hydroxide solution using methyl orange as an indicator. A blank determination was carried out exactly as above, but instead of sample powder, 5 mL of distilled water was used;

$$\text{Protein (\%)} = \frac{0.014 \times 100 \times (X-V)\, N_A}{w} \times 6.75$$

Where,

x = volume (mL) of NaOH solution used in blank

v = volume (mL) of NaOH solution used in test

NA = Molarity of NaOH solution

w = Weight (g) of the sample

0.014 = Milliequivalent weight of the nitrogen

Quality control

A control sample was analyzed during each analysis, triplicates were also run during each analysis and lastly a blank was run.

3.12.7 Determination of Crude Fibre Content

(UIRI Analytical Laboratories Quality Manual, 2024)

Reagents

- 98% concentrated to 1000ml with distilled water sulphuric acid (H_2SO_4)
- 12.5g of KOH to 1000ml with distilled water
- n-octanol as antifoam
- anhydrous acetone
- crucibles

Procedure

The sample moisture was determined by heating in an oven at 105^oC to constant weight and cooled in desiccator. 1g of grinded sample was weighed and 1.25% sulphuric acid added to it up to 150ml notch after preheating by the hot plate in order to reduce the time for boiling. 3-5 drops of n-octanol as an antifoam agent were added and boiled for 30 minutes. A vacuum was connected to drain the sulphuric acid. It was washed 3 times with 30ml of hot deionised water, connecting each time to the compressed air for stirring the content of the crucible. After the last was drained, 150ml of preheated potassium hydroxide were added and 3-5 drops of antifoam. It was then boiled for 30 minutes, filtered and washed as point 7. A last washing was performed with cold deionized water aimed to cool crucibles and the crucible content washed three times with 25ml acetone, stirring each time by compressed air. The crucibles were removed and dry weight after drying was determined after drying in an oven at 105^oC for an hour. They were allowed to cool in a desiccator and the weight obtained was a representative of crude fibre plus ash(F1). The crucibles were then placed in a muffle furnace and heated up to 550^oC for three hours and reweighed after cooling in desiccator (F2). The difference in weight in comparison to point 12 represented the crude fibre content.

%Crude fibre= (F1-F2)/F0*100

3.12.8 Determination of Total Carbohydrates

This was determined by the Deduction method using the formula;

Total Carbohydrates = 100% - %M.C -% Protein - %Fat - % Ash - % Fibre

3.13 Determination of consumer acceptability of the soursop pulp yogurt and soursop pulp-lime yogurt

This was carried out in the Food Science and Technology Laboratory of the Uganda Christian University, Mukono, Uganda in a day.

3.13.1 Choice of panelists and instruction of panelists

A total of 41 panelists were selected (citation missing), and all were yogurt consumers. Each was taught briefly on how to fill in the consumer acceptability sheet by defining each term and how they were supposed to convert their preferences into scores using the 9-point hedonic scale. They were also taught to rinse their mouths between samples for proper precision of the tastes of the samples.

The tasting was done before lunchtime to ensure sensitivity of the panelists to the taste of the samples since the level of satiety affects precision in taste. (citation)

3.14 Sample preparation

Random codes were generated for each sample in order to reduce biases as much as possible. For each sample, six different codes were generated as follows for easy identification during data analysis;

Sample 1 (Each code contains exactly one "4"; no 3, 1, or 6, 2% lime juice)

742, 948, 524, 804, 470, 249

Sample 2 (Each code contains exactly one "1"; no 3, 4, or 6, 0% lime juice)

120, 519, 812, 901, 710, 251

Sample 3 (Each code contains exactly one "6"; no 3, 4, or 1, 3% lime juice)

602, 560, 268, 907, 806, 762

2 tablespoons of each sample were added to a white plastic cup for each panellist, and the samples were placed on a sample tray that had a glass of drinking water for the panelists to rinse their mouth between samples and a white plastic spoon for testing.

3.15 Sample setup and tasting

The samples were distributed to each panelist in a random order with sufficient spaces between panelists to prevent biases. Panelists of close affiliation were not allowed to sit close to one another to reduce biases. Each panelist was handed a ballot where they were to score their opinions on the sensory attributes of taste, consistency, colour, aroma, mouthfeel, overall taste, overall acceptability, and tangy taste using a 9-point hedonic scale from 1 being “much dislike” to 9 being “very much like”

3.16 Statistical analysis of results

3.16.1 Acceptability performance of soursop pulp yogurt

Descriptive statistics showing mean scores for each attribute were obtained using Microsoft Excel and a bar graph was drawn to show the baseline acceptability of the soursop pulp yogurt.

3.16.2 Comparison between soursop pulp-lime yogurt and conventional fruit yogurt

A one sample t test was done to compare the fat, vitamin C, fibre, carbohydrate and protein content of the two sample treatments because only two samples were being compared and it was being done between conventional yogurt (which had standard means of nutrients from the yogurt population) and the soursop pulp- lime yogurt. Descriptive analysis of means, standard deviation was done using Microsoft Excel and the results were inputted into the statology software to carry out the t test and the p value from comparison of each attribute obtained was used to determine whether the two treatments were significantly different from each other for each attribute. If the p value was greater than 0.001, then the samples were not considered significantly different from each other in that nutrient, if the p value was less than 0.001, the samples were significantly different from each other in that attribute.

3.16.3 Determination of consumer acceptability of soursop pulp yogurt and soursop pulp- lime yogurt

An Analysis of Variance (ANOVA) was done since more than two treatments were being compared. This was done in Microsoft excel using a one-way ANOVA since only one treatment was being varied to be obtain descriptive statistics such as means and standard deviation (SD). The alpha used was 0.05 to determine the level of significance. P values from the ANOVA table that were greater than 0.05 showed that there were not significant differences in the acceptability of those samples in that given sensory attribute. Subscripts were assigned to the means and means with the same subscripts were not significantly different from each other down a given column.

CHAPTER 4

4.0 RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 Acceptability performance of soursop pulp yogurt

Table 1 SHOWING THE PERFORMANCE OF SOURSOP PULP YOGURT

COLOUR	AROMA	CONSISTENCY	TANGY TASTE	OVERALL TASTE	MOUTH FEEL	OVERALL ACCEPTABILITY
6.805	6.171	6.488	5.390	5.707	5.756	5.902

A graph showing the performance of soursop pulp yogurt

Figure 4 A graph showing the performance of soursop pulp yogurt

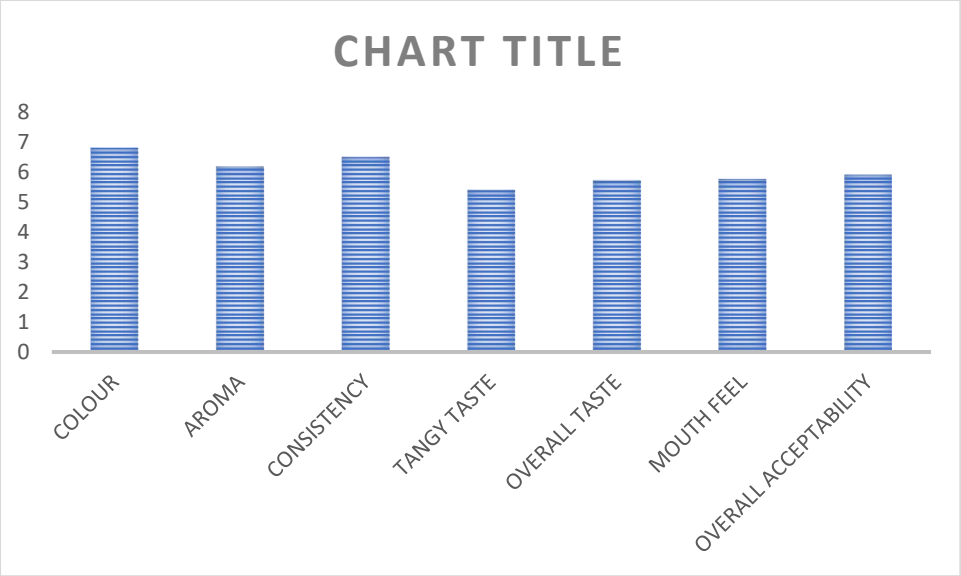


Table 2 SHOWING THE NUTRIENT COMPOSITION OF SOURSOP PULP-LIME YOGURT AND CONVENTIONAL STRAWBERRY FRUIT YOGURT

Treatment	**Protein(g)**	**Total fat(g)**	**Total carbohydrates(g)**	**Total fibre(g)**	**Vitamin C(mg)**

T1(soursop pulp-lime yogurt) 3%	3.65± 0.006	3.19±0.0003	9.3±0.001	0.15± 0.0005	11.93± 0.009
T2(strawberry fruit yogurt)	3.4	3	18.3	0.068	1.68
p Value	<0.001	<0.001	<0.001	<0.001	<0.001

Means, means ± SD, P value is 0.005

4.3 Determination of consumer acceptability of soursop pulp yogurt and soursop pulp-lime yogurt

Table 3 SHOWING CONSUMER ACCEPTABILITY OF SOURSOP PULP YOGURT AND SOURSOP PULP- LIME YOGURT

Treatment	Colour	Aroma	Consistency	Tangy taste	Overall taste	Mouthfeel	Overall Acceptability
T1(0%lime juice)	6.5^{a}±1.45	5.8^{a}±1.39	5.8^{a}±1.90	5.8^{a}± 1.84	6.1^{a}±1.76	6.3^{a}±1.8	6.4^{a}±1.98
T2(2%lime juice)	6.5^{a}±1.36	6.4^{a}±1.38	6.2^{a}±1.30	6.2^{a}± 1.98	6.5^{a}±1.94	5.9^{a}±2.04	6.1^{a}±1.93
T3(3%lime juice)	6.8^{a}±1.49	6.2^{a}±1.99	6.5^{a}±2.01	5.4^{a}± 2.43	5.7^{a}±2.03	5.8^{a}±2.05	5.9^{a}±1.99

Means ± SD, α=0.05, means with same superscripts down the column are not significantly different.

4.2 Discussion of results

4.2.1 TABLE 1

The soursop yogurt performed averagely well across all measured attributes, with scores ranging approximately between 5.5 and 6.5 out of 7. This indicated a generally positive consumer acceptance across all sensory attributes. Colour received one of the highest ratings (approximately 6.5), suggesting consumers found the visual appearance of the soursop yogurt particularly appealing.

Tangy Taste received the lowest rating (approximately 5.5), though it was still a positive. This was most likely due to the strong taste from the soursop, as mentioned by some panelists. This might indicate that while consumers generally accepted the taste profile, the specific tanginess of the soursop yogurt could potentially be adjusted to better meet consumer preferences. Consistency, Aroma, Overall Taste, Mouthfeel, and Overall Acceptability all scored similarly (approximately 6.0), demonstrating balanced sensory characteristics.

The Overall Acceptability score (approximately 6.0) aligns with the average of most other attributes, suggesting that in general, the acceptability of the yogurt was slightly above the average score and therefore the yogurt was slightly good.

4.2.2 TABLE 2

The p-value is less than 0.001 for protein, total fat, total carbohydrate, total fibre, and vitamin C. This indicated that there is a significant difference in the protein, total fat, total carbohydrate, total fibre, and vitamin C content of the soursop pulp-lime yogurt (3%) and that of the strawberry fruit yogurt. Strawberry fruit yogurt was chosen for the comparison because the addition of fruits to yogurt increases fibre and vitamin C content in yogurt, which are absent in non-fruit sweetened yogurts, so its nutritional properties are the closest to those of soursop pulp-lime yogurt.

It was also observed that the protein content in the soursop pulp-lime yogurt was 0.25g higher (slightly higher) than that in strawberry fruit yogurt, and this was because soursop naturally contains proteins (Makebe Calister Wingang, 2021). In addition, the fat content in the soursop pulp-lime yogurt was 0.19g higher (slightly higher) than that of the strawberry fruit yogurt because soursop, being a fruit, naturally contains traces of natural oils (Nguyen T.T *et al*, 2020). The total carbohydrate content was 9g less than that of the strawberry fruit yogurt, indicating a reduction in sugars. The total fibre content in the soursop pulp-lime yogurt was slightly higher than that of strawberry fruit yogurt. Last but not least, the vitamin C content in the soursop pulp-lime yogurt was 10.25g higher than that in strawberry yogurt. This was because both soursop and lime are naturally rich in vitamin C (Prasetyo, C., & Candra, A., 2017).

4.2.3 TABLE 3

The sensory evaluation results for the three treatments (T1: 0% lime juice, T2: 2% lime juice, and T3: 3% lime juice) revealed variations in sensory attributes such as colour, aroma, consistency, tangy taste, overall taste, mouthfeel, and overall acceptability. The colour scores ranged from 6.3 ± 1.45 (T1) to 6.8 ± 1.49 (T3). T3 (3% lime juice) had the highest colour score, which suggested that the addition of lime juice enhanced the visual appeal of the product. However, the differences among treatments were not statistically significant, as indicated by the shared superscripts.

Aroma scores were highest for T2 and lowest for T3. While T2 showed a slight improvement in aroma compared to T1, the differences were not significant across treatments. This indicates that lime juice addition did not affect the aroma perception. The consistency improved with increasing lime juice concentration, with T3 scoring the highest compared to T1 because lime juice breaks down proteins and fibre. However, the difference between treatments was minimal and statistically insignificant, suggesting that lime juice had a limited effect on this attribute.

Tangy taste scores increased from T1 to T2, but decreased in T3. Feedback from the panelists suggested that most attributed the tangy taste to the strong flavor of the soursop, and so 2% lime juice had done little to overpower the strong flavor from

the soursop, but 3% lime did have a better effect on counteracting the strong soursop taste hence the decrease in the tangy taste. The differences were not statistically significant but highlight a potential threshold for acceptable tanginess. The overall taste was rated highest for T2, followed by T1 and lowest for T3, but the differences were minimal and therefore suggested that lime juice had a negligible impact on the overall taste.

Mouthfeel scores decreased slightly with increasing lime juice concentration, from T1 to T3. The differences were minor and not statistically significant, suggesting that lime juice addition had a negligible impact on this sensory attribute. Overall acceptability followed a similar trend to overall taste, with T2 scoring the highest, followed by T1, and T3 scoring the lowest.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

This study aimed to produce a sugar-free yogurt using soursop pulp as a natural sweetener and lime juice as a flavorant, assessing their impact on the yogurt's nutritional, sensory, and physicochemical properties. The specific objectives included determining the vitamin C, protein, carbohydrate, fat, and fibre content of the soursop pulp-lime yogurt compared to conventional fruit yogurt, and evaluating the consumer acceptability of the developed yogurt.

The physicochemical analysis revealed significant differences ($p < 0.001$) in protein, total fat, total carbohydrate, total fibre, and vitamin C content between the soursop pulp-lime yogurt and a strawberry fruit yogurt used for comparison. The soursop pulp-lime yogurt exhibited slightly higher protein and fat content, which can be attributed to the natural composition of soursop. Notably, the carbohydrate content was significantly lower, indicating a reduction in sugars due to the substitution of refined sugar with soursop pulp. The fibre content in soursop pulp-lime yogurt was slightly higher than that in conventional strawberry fruit yogurt and this suggested that soursop contains a higher quantity of fibre than strawberry fruit. In addition, the vitamin C content was also higher in the soursop pulp-lime yogurt, which can be attributed to the inherent Vitamin C content of soursop and lime.

The sensory evaluation of the yogurt with varying concentrations of lime juice (0%, 2%, and 3%) showed variations in sensory attributes. Colour scores were highest for the 3% lime juice treatment, suggesting enhanced visual appeal, but the differences were not statistically significant. Aroma scores were slightly improved with the 2% lime juice, but again, the differences were not significant. The consistency improved with increasing lime juice concentration, although the effect was minimal. The tangy taste was highest with the 2% lime juice, but decreased with 3%, possibly because higher lime juice concentration overpowered the tangy taste from the soursop pulp. The consistency scores increased consistently across all treatments probably due to the fact that acidity leads breakdown of proteins and fibre forming a smoother consistency. The overall taste was rated highest for the 2% lime juice, suggesting that moderate addition enhanced the flavor profile, while the 3% concentration had a negative impact. The mouthfeel had a slight and consistent

decrease across all treatments due to increase in the astringent taste from the lime juice, and the overall acceptability was highest for the 2% lime juice.

5.2 Conclusions

The first null hypothesis stated that there is no difference in the vitamin C, protein, carbohydrate, fat and fibre content of soursop pulp-lime yogurt and that of conventional fruit yogurt but the results showed that there was a significant difference in the nutrient content of the two yogurt treatments and therefore we reject the null hypothesis.

The second null hypothesis stated that there is no difference in the consumer acceptability of soursop pulp yogurt and soursop pulp-lime yogurt. The results showed there was no significant difference in the consumer acceptability of soursop pulp yogurt and soursop pulp-lime yogurt and hence we do not reject the hypothesis.

Overall, the study demonstrated that soursop pulp can effectively replace refined sugar in yogurt production, resulting in a product with comparable or improved nutritional properties. The addition of lime juice at a 2% concentration enhanced the sensory attributes and overall acceptability of the yogurt.

Soursop pulp-lime yogurt has a distinct nutritional profile compared to conventional strawberry fruit yogurt. It is slightly higher in protein and fat (due to the natural composition of soursop), significantly lower in carbohydrates (due to sugar substitution), and higher in fibre and vitamin C (due to soursop and lime). This yogurt offers a potentially healthier alternative with reduced sugar content and increased micronutrients.

The addition of lime juice at a 2% concentration (T2) improved the sensory attributes and overall acceptability of soursop pulp yogurt. While colour and consistency improvements were observed with a 3% concentration (T3), the tangy taste became less appealing, negatively impacting the overall taste and acceptability. The 2% lime juice concentration strikes a balance, enhancing the flavor profile without overwhelming the soursop taste.

5.3 Recommendations

To increase the accuracy and reliability of the results, future studies should replicate this research if they are to use a Completely Randomized Design (CRD). CRD can help to minimize variability and provide more robust statistical analysis.

Further research should focus on optimizing the amount of soursop pulp used to ensure better sweetness and overall taste. Varying the concentration of soursop pulp and conducting sensory evaluations can help determine the optimal level that provides adequate sweetness without compromising other sensory attributes.

Given that aroma scores were relatively lower for all treatments, future research could explore the addition of natural aromas like maple syrup for a natural caramel colour and aroma or different varieties of lime to boost the aroma.

Since mouthfeel also received moderate scores, more maxigel could be added to the yogurt to improve the texture and mouthfeel.

Further research can be carried out on the use of other citrus fruits, such as lemon juice or orange, which could offer better sensory attributes than lime juice.

Further studies can also be done on the microbial quality of the yogurt to determine its shelf life and stability of sensory attributes for a given period of time.

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Appendix 2; BUDGET

Item	Estimated cost (UGX)
Soursop fruits	40,000
Cow's milk	20,000
Transportation	30,000
Limes	3,000
Yoghurt starter culture	100,000
Packaging materials	8,000
Proximate analysis	120,000
Transport	540,000
Total estimated cost	861,000

APPENDIX 3; TIME FRAME

Day	Activity
1-8	Ingredient sourcing and selection
9-10	Ingredient reception and preparation
11-12	Preparation of the yogurt batches
13	Sensory evaluation
14-15	Raw data entry into excel sheet from sensory evaluation
15-28	Nutritional analysis at UIRI
30-34	Data analysis
34-40	Dissertation writing
40- onwards	Dissertation review and submission

APPENDIX 4; ANOVA TABLES

TABLE 1(2%LIME JUICE); A TABLE SHOWING MEANS AND STANDARD DEVIATION FOR SOURSOP PULP-LIME YOGURT NUTRIENT ANALYSIS

Yogurt sample	Protein	Vitamin C	Fibre	Total Fat	Total Carbohydrates
1	3.6521	11.92	0.1498	3.1882	9.2505
1	3.6373	11.92	0.1485	3.1877	9.2519
1	3.6488	11.94	0.1489	3.1885	9.2511
Mean	3.646067	11.92667	0.149067	3.188133	9.251166667
Standard Deviation	0.006344	0.009428	0.000544	0.00033	0.000573488

TABLE 2; A TABLE SHOWING MEANS AND STANDARD DEVIATION FROM OVERALL ACCEPTABILTY SCORES FOR EACH ATTRIBUTE PER SAMPLE

1) **FOR SAMPLE 1**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*	*Standard Deviation*
SAMPLE NUMBER	41	41	1	0	
COLOUR	41	268	6.536585	1.854878	1.361939077

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*	*SD*
SAMPLE NUMBER	41	41	1	0	

					1.90243
AROMA	41	264	6.439024	9	1.379289319

SUMMARY					
Groups	*Count*	*Sum*	*Average*	*Variance*	*SD*
SAMPLE NUMBER	41	41	1	0	
CONSISTENCY	41	253	6.170732	1.695122	1.301968

SUMMARY					
Groups	*Count*	*Sum*	*Average*	*Variance*	
SAMPLE NUMBER	41	41	1	0	
TANGY TASTE	41	254	6.19512 2	3.910976	1.97761 9

SUMMARY					
Groups	*Count*	*Sum*	*Average*	*Variance*	*SD*
SAMPLE NUMBER	41	41	1	0	
OVERALL TASTE	41	265	6.46341 5	3.754878	1.93775 51

SUMMARY					
Groups	*Count*	*Sum*	*Average*	*Variance*	*SD*
SAMPLE NUMBER	41	41	1	0	
MOUTH FEEL	41	240	5.85365 9	4.178049	2.04402 28

SUMMARY					
Groups	*Count*	*Sum*	*Average*	*Variance*	*SD*
SAMPLE NUMBER	41	41	1	0	
OVERALL ACCEPTABILITY	41	250	6.097561	3.740244	1.933971

SAMPLE2(0% LIME JUICE);

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*	*SD*
SAMPLE NUMBER	41	82	2	0	
COLOUR	41	267	6.512195	2.106098	1.45124

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*	*SD*
SAMPLE NUMBER	41	82	2	0	
AROMA	41	236	5.756098	1.939024	1.392489

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*	*SD*
SAMPLE NUMBER	41	82	2	0	
CONSISTENCY	41	237	5.780488	3.62561	1.904103

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*	*SD*
SAMPLE NUMBER	41	82	2	0	
TANGY TASTE	41	236	5.756098	3.389024	1.84093

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*	*SD*
SAMPLE NUMBER	41	82	2	0	
OVERALL TASTE	41	251	6.121951	3.109756	1.76345

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*	*SD*
SAMPLE NUMBER	41	82	2	0	
MOUTH FEEL	41	258	6.292683	3.112195	1.764141

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*	*SD*
SAMPLE NUMBER	41	82	2	0	
OVERALL ACCEPTABILITY	41	264	6.439024	3.902439	1.975459

SAMPLE 3 TABLES (3% LIME JUICE);

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*	*SD*
SAMPLE NUMBER	41	123	3	0	
COLOUR	41	279	6.804878	2.210976	1.486935

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*	*SD*
SAMPLE NUMBER	41	123	3	0	
AROMA	41	253	6.170732	3.945122	1.986233

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*	*SD*
SAMPLE NUMBER	41	123	3	0	
CONSISTENCY	41	266	6.487805	4.056098	2.013976

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*	*SD*
SAMPLE NUMBER	41	123	3	0	
TANGY TASTE	41	221	5.390244	5.893902	2.427736

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*	*SD*
SAMPLE NUMBER	41	123	3	0	

OVERALL TASTE	41	234	5.707317	4.112195	2.027855

SUMMARY					
Groups	*Count*	*Sum*	*Average*	*Variance*	*SD*
SAMPLE NUMBER	41	123	3	0	
MOUTH FEEL	41	236	5.756098	4.189024	2.046711

SUMMARY					
Groups	*Count*	*Sum*	*Average*	*Variance*	*SD*
SAMPLE NUMBER	41	123	3	0	
OVERALL ACCEPTABILITY	41	242	5.902439	3.940244	1.985005

Appendix 5;

CONSUMER ACCEPTABILITY BALLOT FOR SOURSOP PULP YOGURT.

Panelist No: Date: _____ Sex: _____

INSTRUCTIONS:

You are provided with pineapple homemade jam. Test each sample and express your degree of liking for a specific attribute using a VALUE that corresponds to this degree from the hedonic scale provided below.

Score the product using the hedonic scale below:

9 - Like extremely
8 - Like very much
7 - Like moderately
6 - Like slightly
5 - Neither like nor dislike
4 - Dislike slightly
3 - Dislike moderately
2 - Dislike very much
1 - Dislike extremely

Instruction; After each sample, rinse your mouth properly with the drinking water provided before testing another sample.

Quality attributes	**Sample No**			
Color				
Aroma				
Consistency				
Lime(tangy) taste				
Overall taste				
Mouthfeel				
Overall acceptability				

Which sample (only one) would you buy and why?

……
……
……
……..

General comments

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Appendix 6;
Sample preparation and Consumer acceptability